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FEATURES

Rowley Mine Wulfenite 12
This Arizona source was a collector's paradise
by Bob Jones

The Frugal Collector:
The Silicates 20
Part I: The axinites, babingtonite, neptunite, and datolite
by Bob Jones

Beyond Cabbing 28
Freeform agate carving gives freedom of choice
by Tom Harmon

Roadside Panning Sites in Utah 34
Part II: Salt Lake, San Juan, Sevier, Uinta, Utah, Washington, and Wayne counties
by David and Clois Walker

Rock & Gem Kids 46
Fluorite and a Mohs hardness test kit
by Steve Decker

Liquidating a Rock Hobby Estate 60
Part II: Holding a sale without getting burned
by Larry G. Field

Collecting Sapphires in Southeast Asia 64
Tourist opportunities in Thailand, Cambodia and Laos
by David Bright

Volcanic Iceland 80
It's a geological hot spot
by Kiera Tara O'Brien

FIELD TRIPS

Dogtooth Mercenaria 40
Collecting calcite-filled clams at Rucks' Pit, Florida
by Everett Harrington

Phosphate Fossil Treasures 50
Easy pickings on South Carolina's coastal plain
by Richard J. Jacquot

Rockhound's Honeymoon 72
Gem panning and petrified forests
by Kenneth H. Rohn

REGULAR COLUMNS

Craftsman of the Month 6
Show Dates 8
Shop Talk 18
Off the Dop 26
Picks & Pans 48
Subscriber Service Information 76
Rock Science 76
Many Facets 78
On the Rocks 88

ON THE COVER

This textbook crystal specimen of wulfenite from Arizona's Rowley Mine resides in the Houston Museum of Natural Science. (Photo by Jeff Scovil) Sapphire image courtesy www.thaigem.com.

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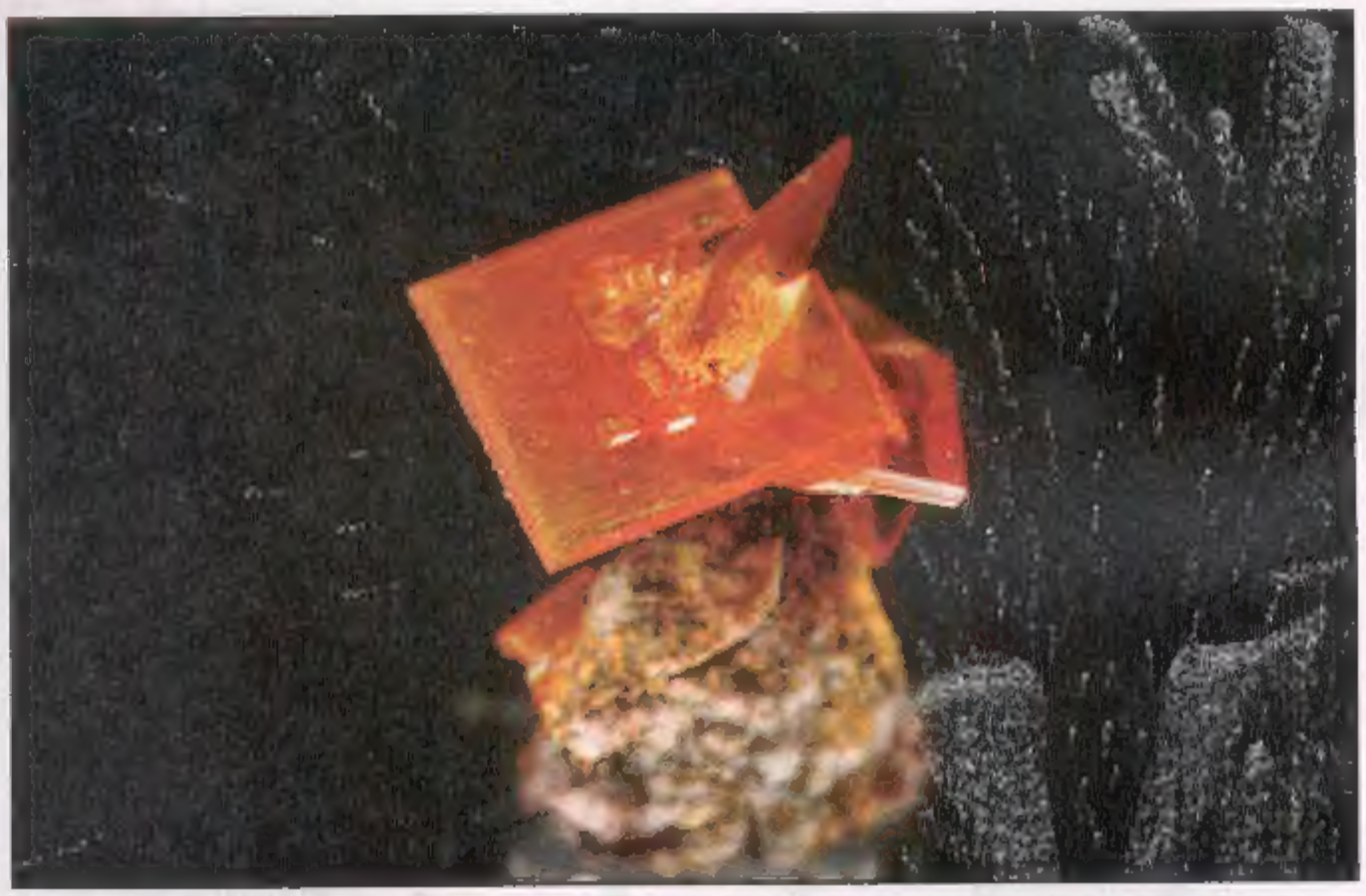
Rowley Mine Wulfenite

This Arizona Source Was a Collector's Paradise

Story and Photos by Bob Jones



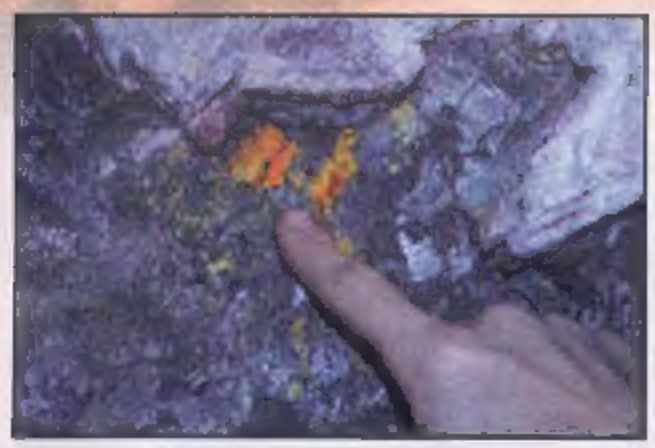
A thumbnail of superb wulfenite has needle mimetite at the base of the vertical crystal.

While Arizona's Red Cloud, Defiance, Glove, and other wulfenite mine sources are more famous, the Rowley Mine has given more collectors success in collecting wulfenite than any other. Of all these mines, the Rowley has been most accessible to collectors and the steadiest rewarder of collector's efforts in the latter half of the 20th century. Countless collectors have enjoyed digging its colorful wulfenite, mimetite, and uncommon lead minerals.

Located in the Painted Rock Mountains, the Rowley Mine's underground workings are "painted" with colorful mineral species. Even today, though the property is closed to collectors, the deposit provides the mineral market, through commercial mining, with bright yellow, orange, and red-orange windowpanes of lead molybdate. Occurring with the wulfenite, the equally colorful species mimetite forms crusts and velvety coatings that range from yellow to orange and even red! This gives you some idea of why the Rowley has always been extremely popular with collectors. The crystals of mimetite are usually tiny and the wulfenites seldom exceed an inch on an edge, but their small size is offset by the intense color seen in the better specimens. Through the decades, when collectors went underground, seams and cracks lined with colorful minerals were just waiting to be collected.

While it is true that the Rowley wulfenites seen today are never large, averaging maybe a half-inch on an edge, early reports mention crystals to 2 inches on an edge. What makes the Rowley near and dear to so many collectors is the fiery orange color and glass-clear tabular blades of this lead molybdate. The sheer abundance of specimens and the ready accessibility to the underground workings have made the Rowley an intensely collected site. Active local collecting has extended from the early part of the 20th century to that century's end, when the property was closed and commercial collecting commenced. Though the property is no longer accessible to the average collector, the results of commercial mining here have actually increased the supply of fine wulfenite and mimetite specimens. In addition, formal mining has brought to light a variety of uncommon lead species, and it's possible that one or two really rare species will turn up.

I was one of those fortunate Arizona collectors who repeatedly went underground at the Rowley. My first visit was in 1961, only a couple of years after I moved to Arizona. Having collected primarily in pegmatite deposits when I lived back east, I experienced quite a thrill when I first looked into an open seam lined with brilliant orange wulfenites! No wonder I kept coming back to the Rowley. We knew that every time we went underground we would have a successful day.



A small pocket of velvet mimetite contrasts markedly with the host barite.

Hard work pays off in the form of wulfenite on mimetite.

The crystals on this 4-inch-wide specimen of vanadinite show a hoppered effect.

A 4½-inch vug filled with superb wulfenite on barite took 18 hours to dig out.

Once underground, we simply had to decide not where to dig, but which open vein lined with wulfenite seemed most accessible and with easier pickings. Looking up at the ceiling of the main tunnel, one could see crack after crack running parallel to the major faults. Each crack was lined with orange blades, never large, but always abundant.

The most difficult problem to solve was how to break up the hard barite matrix without popping the wulfenites off. A visit underground always yielded a fair number of very attractive, colorful, showy specimens of wulfenite and mimetite.

Interestingly, the commercial venture now operating at the Rowley Mine has begun to reveal that the Rowley is far more than a ready source of showy wulfenite. It is, in fact, a treasure trove of uncommon and rare lead and copper species. At last, someone is doing scientific studies of the Rowley's mineralogy, and the results will be most useful in establishing the Rowley as a valid source of uncommon and rare lead and copper species. Species such as boléite, diaboléite, caledonite, and leadhillite have already been collected, and there are unknowns being studied now. Crystals of these unusual secondary species are never large, making the place a micromounter's dream deposit! Fine, often perfect crystals of rare species occur side by side in pleasing associations.

Commercial specimen mining at the Rowley has been successful in recent months. Anyone who visited Denver during the September 2005 show saw remarkable examples of recently mined specimens of wulfenite and mimetite.

The Rowley deposit consists of two main mineralized veins that run more or less parallel to each other. One is a quartz vein, which collectors found difficult to work. The more easily worked vein is of massive white barite. Small pockets in the barite offer nice, small clusters of bladed barite, along with the more eagerly sought colorful lead minerals. The barite vein has attracted most of the attention from collectors, as it is easier to work and it holds the deposits of primary lead and copper sulfides that, through weathering, ultimately produced secondary species. Headed by wulfenite, mimetite and vanadinite, the Rowley secondary minerals form a lovely suite.

While exceedingly colorful wulfenite and mimetite have always been the primary targets of collectors at the Rowley, on rare occasions, mining would encounter exciting, small pockets of a marvelous suite of the less common to rare lead minerals. This latest commercial effort is important, as it sheds more light on this uncommon and rare suite of lead and copper minerals.

continued on next page

Initially, these microcrystals did not excite most amateur collectors, as the more colorful discrete crystals of wulfenite and mimetite overshadowed them, but these days more attention is being paid to the rare and uncommon minerals the deposit yields. So far, mining has brought to grass such superb collector species as leadhillite, boléite, caledonite, linarite, diaboléite, and atacamite. There is also the potential of the suspected rarities that have come to light, but have yet to be identified. One recently found unknown could be pinalite, a lead, tungsten chloro-oxide, first found in the rare suite of minerals from the Mammoth-St. Anthony Mine at Tiger, Pinal County, Arizona. The suspected pinalite is currently being X-rayed and tested.

The popularity and attractiveness of wulfenite and mimetite, as well as their abundance, distracted local collectors from concentrating on the Rowley's uncommon species. The group doing the commercial mining here is much more cognizant of the importance of documenting the mineralogy of the deposit. They are also well aware that such rare species are much more popular now among collectors and micromounters.

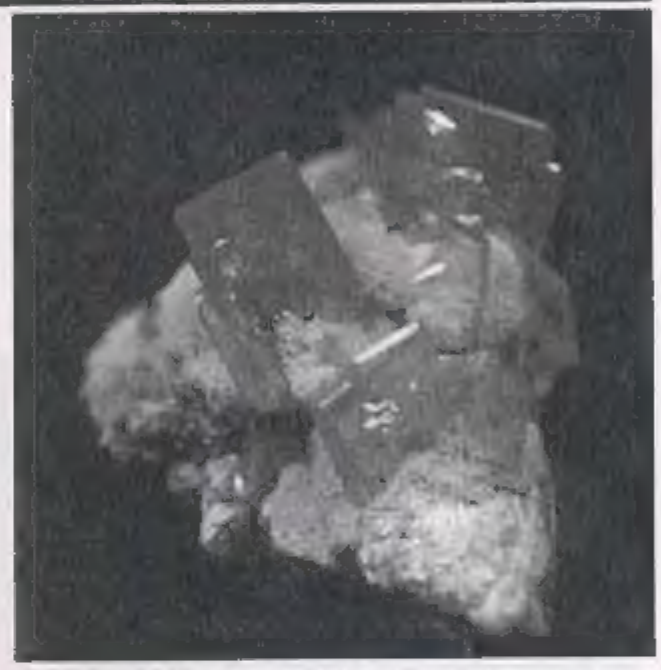
The wulfenite from Rowley ranges from yellow to yellow-orange to orange-red. The blades are typically tabular with minor modifications, though some approach a pyramidal form. Others are found with quite varied modifications. Their size is usually ½-inch, though superb 1-inch crystals are not uncommon as mining proceeds.

The deposit was originally mined for its lead minerals; wulfenite was the main ore. During mining, some 30 *tons* of wulfenite concentrate (crystals) was shipped. This attests to the abundance of this lead molybdate mineral in the deposit.

The barite vein runs from 15 to 30 feet in width. It is heavily fractured, so small openings and seams were available for crystal growth. Even during recent mining, crystal-lined vugs as wide as a foot across have been opened. My son Evan Jones and Jim Ricker, who is now one of the mine operators, spent something like 18 hours removing one vug filled with fine wulfenite and mimetite. It was extracted as a huge block of barite and later reduced to a cabinet-size specimen to display the wulfenite/mimetite content to best advantage. The piece was later seen publicly as part of a wulfenite display at the 2005 Tucson Gem & Mineral Show.

The host barite is not only a much fractured matrix rock, but also occurs crystallized. With wulfenite, mimetite, and sometimes vanadinite crystals perched on a massive white barite matrix, the occasional small, crystallized pocket of barite blades provides a very nice background for the several colorful species.

A collector's most difficult problem was how to break up the hard barite matrix without popping the wulfenites off.



Red wulfenite blades are randomly arranged on bright yellow mimetite in this 2-inch specimen.

Barite seems to have crystallized parallel to the fracture pattern. Later movement has fractured and twisted the more or less parallel barite layers. It is within these fractured areas that small pockets can be found containing nice, small barite blades and the more desirable and colorful secondary minerals.

The barite crystals generally lack color, ranging only from white to dull gray. The exception is those crystals lightly stained with the reddish iron oxide hematite. Anyone working in the mine for any length of time emerges well dusted with this reddish mineral. It gets into every fold of your clothing and requires vigorous scrubbing to get it out of your flesh!

The barite crystals occur as tightly packed blades measuring to nearly an inch long and a few millimeters thick. Such blades are profuse in some cracks and pockets, but individual crystals are never large, even on specimens that are 6 inches or more across.

A second type of barite, introduced after hydrothermal action brought in the lead sulfide, can be seen using a hand lens. These barium sulfates are colorless, clear and very small, just a couple of millimeters long. They are found on the earlier-formed barite and also may be seen on wulfenite and mimetite crystals.

Rowley mimetite shows much greater variations in its crystal development than the wulfenite. Most common are the rich orange, velvety crusts of mimetite that completely line some openings. Often, choice wulfenite blades have formed on this velvet background, making a wonderful contrast between the two species. Other mimetites show a fascinating, radiating wheat-sheaf form. This variety starts as a small cluster of needles that diverges during growth to resemble a bundle of wheat tied in the middle and fanning out at the terminations. The tips of these mimetites tend to be transparent, while the bases of the crystals are opaque. In the ultimate case, the radiating needles of mimetite actually complete a sphere, forming small balls of orange-red mimetite. The best of these spherules are found resting on the edges of the wulfenite blades.

Still another form of mimetite is bright-yellow, hairlike needles randomly scattered over the surface of the white barite. These mimetites have developed on the edges of wulfenite crystals, adding their yellow to yellow-orange color to the arrangement. Though discrete crystals of mimetite are seldom found, the hairlike and velvety crystals, coupled with the small sheaflike and spherule growths, make mimetite a significant member of the Rowley suite of minerals.

The original solutions that brought in the primary copper and lead minerals, mainly in the form of galena and chalcocite, contained only traces of a zinc mineral. This means the only evidence of zinc found so far is in scattered occurrences of descloisite, a lead, zinc vanadate. This dark-brown to tan species is found only rarely.

The mineralized hydrothermal solutions also brought in minor amounts of the precious metals gold and silver. Some of the silver ended up in the rare silver sulfosalt boléite, a copper, lead, silver mineral. In rare instances, small wires of silver have been encountered, usually as single wires associated with other minerals. Gold is found sparingly in microscopic bits. Some silver sulfides have also been found, but remain to be definitively identified.

Vanadinite is one of the commonly collected Rowley Mine minerals. It is encountered along the seams and fractures and in pockets in the barite. It is most often found as microcrystals and less commonly as a pseudomorph of wulfenite. The vanadinite occurs as a brown to yellow-brown variety often called "endlichite," which is no longer a valid name. Instead, the material is now referred to as "arsenical vanadinite."

Some yellow hexagonal vanadinites have been collected in millimeter sizes, but the bulk of the vanadinite occurs as microcrusts of crystals, usually brown in color, that sometimes coat the wulfenite.

One area of the mine, referred to as the "Pseudomorph Room" by collectors, has produced remarkable brown to tan vanadinites in tabular form, the crystal shape of the wulfenite it replaces. Other vanadinites that are found less often in the same area are bright red. Therefore, all the secondary species, with the exception of the wulfenite and mimetite and some vanadinite, form as microcrystals in suites, usually as halos around some residual galena, the original primary lead ore.

Pods of massive galena are sometimes encountered and are usually encircled by a variety of uncommon and rare secondary lead/copper species. The galena may well have altered to anglesite first, then to cerussite, according to its usual sequence. This sequence is seen in the Rowley material, in which some anglesite is found often closely associated with cerussite. The angelsite is in crystalline masses. The color of the anglesite and cerussite is usually gray, perhaps due to included residual galena.

One of the fairly common lead, copper species encountered here is caledonite. This occurs as light blue-green granular to crystalline masses, sometimes exhibiting fine, glassy microcrystals. The massive caledonite can extend several inches from the central altered galena core.

Intimately associated with the caledonite is fine, darker blue linarite. It lacks discrete crystals, usually showing a crystalline form. Atacamite occurs within the linarite as a green crystalline material that often has a sandy or rough surface.

One of the quite rare species found in this altered galena suite is boléite. This lovely, dark-blue lead, copper, silver chloride has been found sparingly as massive material. A few exciting microscopic spherules of boléite have also been found in this altered lead suite. The few spherules that have been identified are associated with cerussite. Just as exciting, boléite has also been collected recently in small clusters of micro-cubes.

Diaboléite closely resembles boléite in its chemical makeup, lacking only silver. Diaboélite is usually found in massive form at the Rowley. Some of it shows a gritty or rough surface. Some diaboléite in crystals up to 5 millimeters on an edge have been found recently. Diaboléite is most often seen with linarite and the other lead/copper minerals. That such rarities are now showing up here and being saved and identified is a credit to the care being taken by the commercial mineral miners, who are determined to make this project a scientific success while mining crystals for the collector public.

What makes boléite, diaboléite, linarite, and caledonite a problem at the Rowley is their color: all of them are quite similar shades of blue. The caledonite is the lightest blue with hints of green, an aid in separating it from the others. It is also much more common than the other three. Boléite tends to be the darkest of the blue minerals. What makes color so misleading is the variations that can occur within the chemistry of any given species. What with inclusions, variations in chemistry, and possible effects of weathering, color is not always a useful guide to identifying a species. This is why the current operators of the property are working with two universities, Cal Tech and the University of Arizona, to better establish the identity of the uncommon species, while having the unknowns checked for possible unreported and even new species.

continued on next page

Rowley Mine Wulfenite *from page 15*

One of the more exciting uncommon species found within the Rowley Mine's altered suite is leadhillite. It has been found in platy crystalline masses that show typical pearly luster. Individual crystals were reported in the past, but these were never more than a few millimeters in size.

Leadhillite occurs as subparallel, colorless, crystalline plates, tightly packed and microscopic in thickness, as well as in small, rounded masses. Its typical pearly luster helps identify it, and is best seen where leadhillite has parted or cleaved perfectly.

Several writers have likened the suite of rare lead and copper minerals at the Rowley Mine to a similar suite found in Arizona's world-famous Mammoth-St. Anthony Mine at Tiger. Tiger has produced far more discrete crystals of its rare lead, copper species in much larger sizes, but the chemistry is similar, so the two deposits have much in common. Yet, there are decided differences in the two deposits. To date, Tiger has yielded far more rare and uncommon species. This may be due in part because Tiger has been definitively studied, while the Rowley deposit is just now being scrutinized by professional mineralogists.

The major difference between the two deposits is that the Tiger species developed in a different and more complex paragenesis sequence than those of the Rowley deposit. The Rowley consists of two veins of barite and quartz, both of which are open systems. This means weathering and mineralizing solutions were in no way inhibited from affecting the deposit.

Tiger, on the other hand, produced its rare and uncommon lead and copper species in a closed system after deposition. This system was encased by quartz, which prevented any later, major incursions. This restricted the effects of external influence and allowed more complex chemical reactions to occur. This resulted in the development of a greater variety of species and encouraged the development of larger crystals.

In my early days of collecting at the Rowley Mine, access was really easy. An inclined shaft extended 160 feet to the first level. The shaft was braced with the typical square-set timbers, each about 8 inches wide. A sturdy manway ladder made climbing in and out of the mine a cinch. Unfortunately, some idiot set fire to the timbers in the incline and burned them out! This made entrance a little dicier. Collectors had to rope down a second nearly vertical shaft to reach a second incline. This entrance had a rough, funnel-shaped collar, which made access even more difficult.

Wulfenite does not come any more water clear than these half-inch blades.

Surprisingly, the dumps at the mine seem rather minimal when you consider the amount of original tunneling and mining. The dumps are not very fruitful, though recent mining has produced a significant amount of good chrysocolla. Some of the chrysocolla is of jewelry quality. When the main incline was still intact, some chrysocolla mining was carried on, but that effort was short-lived, as the chrysocolla played out.

On my most recent visit at the invitation of partners Jim Ricker, Ed Davis and Bill Jaeger, I met people from the Cal Tech unit who have been investigating the association and identity of various lead and copper species found. Much discussion was held over specimens that showed the typical sequential alteration halo around an altered lead core. Obviously, there is much X-ray and microprobe work to be done before any definitive answers will be found.

Currently, mining is done largely by hand simply because careful removal of the massive barite is necessary to expose and preserve the fragile species being found. The miners learned by experience to go easy. Early on, they had drilled right into a crystal pocket, seriously damaging the contents. Mining carefully is slow and sometimes frustrating work, but preservation of the crystals is the key to successful specimen mining. The mining team uses power equipment—a diamond saw and a power drill—very sparingly. As soon as any evidence of crystals appears, color indications are followed by hand.

Jim, Ed and Bill are currently concentrating their efforts on the Rowley, but they have stakes in other well-known mines. Jim owns the Glove Mine, the famous wulfenite source south of Tucson at Amado. He is also co-owner, along with Aaron Bankes, of the famous Red Cloud Mine, which has produced Arizona's finest wulfenites.

Jim has also worked the Geronimo Mine, north of Yuma, a relatively unknown but important wulfenite source located near the Red Cloud. The Geronimo is an interesting deposit. It was originally known as the Ronaldo Pacheco Mine, and was a source of choice red vanadinite and wulfenite. Eventually, its exact location was lost and was only re-discovered in the latter part of the 20th century by rockhounds.

When Jim and his team worked the Geronimo Mine, it produced some of the richest red vanadinites and deepest red wulfenites ever found in Arizona. The fine red color of this deposit's species, as well as the red wulfenites from the Red Cloud Mine, owe their color to the transition metal element chromium acting as a chromophore.

I mention these additional wulfenite localities to let collectors know they can relax; a supply of very fine wulfenite, mimetite and other secondary lead minerals will continue to come to grass thanks to the efforts of these mining entrepreneurs of the Arizona Co. These men invest their money and their time in the never-ending search for Arizona wulfenite treasures for the benefit of collectors and museums.

If you want to read a more detailed early account of Arizona's wulfenites, read my three-part series "Colorful Minerals of the Southwest" in the May, July and August 1988 issues of *Rock & Gem*. The January-February 1974 issue of *Mineralogical Record* also has a detailed article on the geology and mineralogy of the Rowley Mine.

In the meantime, keep an eye out for fine Rowley Mine minerals when you go to shows. The team of Ricker, Davis and Jaeger are doing some serious mining at the Rowley, always a very colorful producer of collector minerals.

Shop Talk

by William A. Kappele

Choosing a Diamond Blade

A reader recently sent me an e-mail requesting some information on buying a new saw blade. He had been cutting some Utah agate, got in a hurry, as many do, and dished the blade. Before he wrote me, he had done some homework on the Internet and found that he could get a blade made in China for about $140 or one made by an old-line American manufacturer for $240.

Well, that $100 would buy a lot of Big Macs with fries (or a tank of gas), so naturally, the reader wanted to know the whether the Chinese blade would do as good a job as the American one. I don't know the answer to that one, but I do know that the quality of the tools and machines that I use has been getting better and better. I have no reason to doubt that the same is true of diamond blades.

Since price was one criterion, I first asked the reader if he really needed a 16-inch blade. It turned out that he didn't. Most of his cuts involved material less than 3½ inches. The saw had started life as a 16-incher, so he just naturally thought of replacing the blade with the same size that was on it.

If any of you have looked, you will know that the price of blades, whether Chinese or American, goes up exponentially with the size. For example, if you can use a 14-inch blade, one from the same manufacturer can be about half the price of a 16-inch one. That's quite a hunk of change. If you can use a 12-inch or 10-inch blade, you can save a whole lot more.

Before worrying about where the blade came from, it is essential to decide just what you want the blade to do. There is a mind-boggling array of manufacturers, types of blades, and quality of materials to wade through. The first step is to determine what kind of cutting you are going to be doing. Will you be doing just occasional weekend cutting, or will you be doing serious cutting on an almost daily basis? Will you be rough cutting slabs or trimming precious stones? When you have answered these questions, you can start thinking about things like notched blades vs. sintered ones, laser welded, silver soldered, electroplated, resin bonded, and on and on. You can find information on this stuff at a dealer, on the Internet, or by contacting the various manufacturers.

Ideally, an independent testing facility would take all of the popular blades, including those from China, and run them to destruction under controlled conditions, then publish the rankings. Sadly, I know of no such source, so we are pretty much on our own. Following are a few ideas on how to choose a blade:

1. Try to find a club with its own shop in which the saw(s) get a lot of use and ask which blades give the best service.

2. Look for a shop that does commercial cutting and ask what they use.

3. If price is a factor (as it usually is), and you have a trim saw, buy a couple of smaller blades—maybe a Chinese and an American—and give them your own test. When you find one you like, try a larger one of the same brand.

It's too bad that buying a blade is such a crap shoot, but if you do your homework, you will come out all right.

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle@cox.net, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

THE FRUGAL COLLECTOR

THE SILICATES

Part I: The Axinites, Babingtonite, Neptunite, and Datolite

Story and Photos by Bob Jones

The silicates are the largest single chemical group of minerals found in the crust of the Earth. Some species are so rare that only one or two examples even exist. Others are so common that they constituent the bulk of the Earth's rocks. Quartz and feldspar, for example, can constitute over 90 percent of granite, the rock that makes up the core of the continents.

The more important silicates, like quartz (February, March 2004 *Rock & Gem*) and feldspar (May, June, July 2004 *Rock & Gem*) have already been described in this series. Other silicates have been described individually throughout the Frugal Collector series. Yet, there are still many dozens of fine silicates that are attractive or interesting to collectors and are found in sufficient quantity to be exciting while satisfying market demand. Such species are regularly seen in collections and on display at shows. In fact, the silicates undoubtedly constitute the core of any general collection and are usually the stars of most mineral show exhibits.

This and the several silicate articles that will follow will describe many collector silicates out of the hundreds of species in this chemical group, that have not already been treated and are commonly available to collectors. Obviously, it is impossible to include all silicates so my favorites and those commonly collected will appear in these articles.

Let's begin with the axinites, datolite, babingtonite, and neptunite. Each of these four species can be found on dealers' tables at a full range of prices within the reach of most collectors. They also form very spectacular specimens that appear in competition, are used in special show displays, and are an important part of any broad-based general collection.

There are three recognized axinite types: ferroaxinite is the more important member of the group, which also includes manganaxinite, a fine collector mineral, and magnesioaxinite, a relatively obscure member. The chemistry of the axinites is complex. The basic composition for axinite is a hydrous calcium, aluminum, borate silicate with one element missing. This missing element is a necessary and integral part of the axinite chemistry and its slot could be filled by a trio of elements, from which we get the varieties of axinite.

The Lane Quarry in Westfield, Massachusetts, is well known for sharp, black babingtoninte crystals.

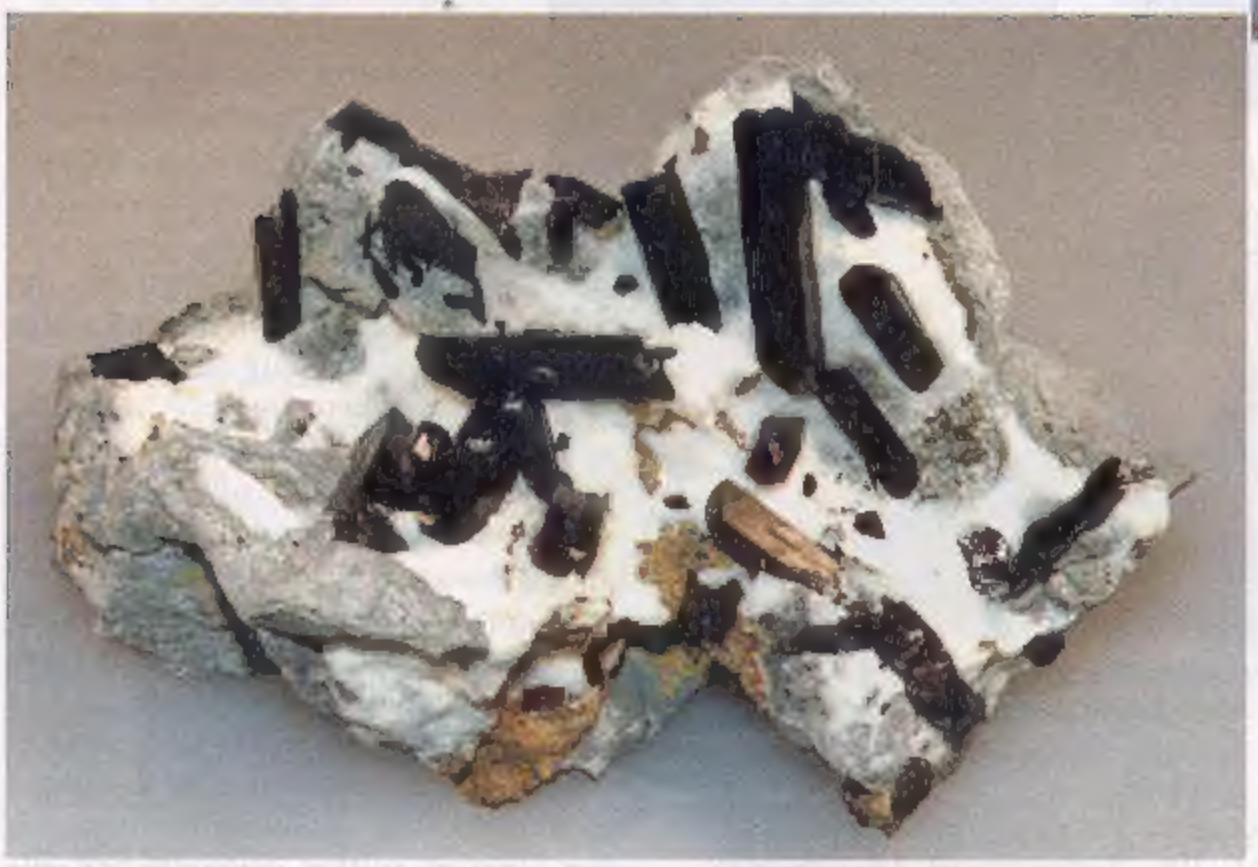
Every axinite has one, and more often two, of the elements manganese, iron and magnesium. They lock into the vacant position to complete the mineral's structure. Iron gives us ferroaxinite, certainly one of the more beautiful and popular axinite group members as you will see. Manganese can substitute for all or some of the iron ions in the structure. When it exceeds or replaces iron, the species is manganaxinite, also a beautiful, very popular, and eminently collectible mineral. The third element, magnesium, can take the place of either manganese or iron, but this happens much less often and the species, magnesioaxinite, is not found in large, attractive quantities like the other two.

If you enter mineral competition in the major shows, you may run into a serious problem when it comes to having a member of the axinite group in your display. If you label the mineral "axinite" and there is a knowledgeable—or should we say fussy—judge in the group looking at your case, you're

SMALE COLLECTION

Digging at the New Melones Dam in California produced some superb axinites.

Russia's Dodo Mine produced a fine suite of alpine-type minerals, including gemmy axinite.



Neptunite crystals from the Gem Mine in San Benito County, California, occur embedded in white natrolite.

SEAMAN COLLECTION SPECIMEN

Included copper colors this datolite nodule from Michigan's Keweenaw Peninsula.

going to get docked points because you did not include the proper prefix to axinite on your label. The fact that you probably couldn't give it the right prefix anyway doesn't matter to some judges.

To solve this problem, you have to refer to the literature to determine whether what you have is ferroaxinite or manganaxinite and hope you are right. That's because the well-known, or more productive, axinite sources, France and Russia, generally produce one type of axinite, but each locality has also yielded the other type. Still, you have to go with percentages.

At Bourg d'Oisans, Isere, France, both manganaxinite and ferroaxinite species have been identified, and there is no way a collector can distinguish one from the other. However, tests show that ferroaxinite dominates the specimens from Bourg d'Oisans. The opposite is true of Dal'Negorsk, Siberia, Russia, which has come online in the last dozen years and produced some really amazing specimens of manganaxinite.

The more recent texts distinguish between the two types of axinite and give the correct locality information, so you can label your French specimen ferroaxinite and your Russian piece manganaxinite. If you are displaying a fluorescent axinite from Franklin, New Jersey, you'd better label it manganaxinite in the interest of accuracy!

We've already established that iron and manganese can share duties in the chemistry of axinite at the same time. For the name to be technically accurate, the amount of iron or manganese in a specimen has to be determined. Whichever element exceeds 50 percent of the specimen determines the species name.

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This whole business of mineral names has become an annoyance of late True, exact species names are important and useful, but I long for the good old days when axinite was axinite and apatite was apatite For decades, there has been no technical differentiation between axinite specimens rich in iron and those rich in manganese Of late, mineralogists have been diligently examining species, partly because we have far more sophisticated equipment that is more exact in understanding the internal structure of minerals That's great, but having been raised on the old terms, I find this entire naming business gives me a headache, especially when recent studies suddenly e iminate a mineral I've known and loved

Now that we've covered the differences in ferroaxinite and manganaxinite and magnesioaxinite, I will refer to all members of the axinite group as "axinite" for the remainder of this discussion.

Axinites have been found in dozens of localities because the mineral commonly forms in any contact metamorphic location that has the right ingredients, particularly boron A second source is any deposit that has experienced boron metasomatism, which simply means the element boron was introduced as part of a later solution infusion This helps change existing material to axinite So axinites were often encountered in a dozen or more mining areas in Europe Because of the passage of time, you don t see anything of these early axinites, except for those from the famous French locality at Saint Christophe, Bourg d'Oisans This axinite locality is on Mount Rocher d'Armentier and has been an important and prolific axinite producer since the 1600s Remarkably, as late as 1989, some fine axinite specimens were mined here by collectors

The Bourg d'Oisans axinites are classics, with their easily recognized blade, wedge or ax shape. In fact, the term axinite was fashioned from the Greek word "axine," meaning "ax "

The French specimens can be clusters up to 6 inches across with fine blades commonly to an inch or more over the entire piece The largest crystals can exceed that size, though the most recent crystals mined tend to average about an inch long They were found on a quartz-epidote schist matrix

The color of Bourg d'Oisans axinite varies through shades of honey-yellow to clove-brown to brown The tips of the specimens are usually lighter colored and transparent, sometimes almost colorless. The core of each crystal tends to be a darker shade With a vitreous luster, these crystals are delightful to own because of their rich color and unique crystal form

Neptunite usually occurs with gemmy benitoite at the Gem Mine in San Benito County, California

Of course, the final question has to do with the chemistry of the French axinites Are they manganaxinites or ferroaxinites? The answer is "either," but you are better off labeling them ferroaxinite as that is the dominant variety found here

The French locality might have been considered the premier source of axinite in the previous century, and it is still producing small quantities of fine specimens even today, but the leading source of this wonderful silicate in the last decade or so has been the bitterly cold Puiva Deposit in the Subpolar Urals of Russia Northeast of Moscow and across the northern end of the Urals is the village of Puiva The deposit isn't far from this remote outpost The climate here is described as "severe" or "extreme," which does not refer to excessive heat!

This deposit is basically an alpine-type metamorphic schist and most collectors today will agree it has been producing the world's finest axinites, many of which outshine the French specimens. In addition, Puiva has yielded some amazing smoky quartz specimens. Many of them are classic gwindels, beautiful, twisting, twinned smokies that were first found in quantity in the Swiss Alps

The Puiva axinites, most of which are ferroaxinites, resulted from hydrothermal action They range from brilliantly lustrous to fairly bright to somewhat dull, though the majority are brilliant. The crystals themselves can be singles showing double terminations or pleasing clusters that are several inches across. Matrix crystals tend to range up to an inch long, and all show the classic wedge or ax shape that is typical of the mineral

The most productive pocket of the Puiva deposit was about 50 feet long and produced an amazing number of some of the best axinites ever found Their color ranges from a light brown to a violet brown to a pale violet I do not know the status of the deposit now.

When these axinites hit the market, they really caused a stir. I can recall being at the Munich Show when one of the first batches of these wonderful crystal groups was offered Buyers were literally lining up to have a chance to get a good specimen. I was lucky enough to ferret out several nice pieces from one Russian dealer's offerings.

Another Russian source, Dal'negorsk, has also produced fine axinites that rival those from the other Siberian source The only real difference here is that the Dal'Negorsk specimens are manganaxinites Dal'negorsk is perhaps better known for several other mineral species, including marvelous fluorite and bright, large crystals of pyrrhotite, but its manganaxinites are just as exciting They are lustrous, sharp, and as colorful as any from the previously mentioned sources. The crystals tend to be about an inch long, are wedge- or ax-shaped, and a lovely dark to light brown In a few cases, the crystals are coated with greenish chlorite. The larger crystals reach 4 inches long and are equidimensional Typically, they appear zoned, as the color is darker in the central part of the crystal and lighter along the edges.

The Dal'Negorsk mining region is about 300 kilometers northeast of Vladivostok, Siberia's most important eastern seaport. Fine crystallized specimens of a number of species, including axinites, began coming from here about 15 years ago, so good specimens are still available.

Among other noteworthy species from Dal'Negorsk are brilliant galenas, some showing spinel twinning, superb, brassy pyrrhotites in bright, hexagonal discs, the earlier-mentioned fluorites, ranging from colorless to green and as much as 4 inches on an edge, and excellent calcites showing many different crystal forms. Large, black dravites and bright pyrites add to the importance of this locality as a collector species source.

Fine axinites were once found in quantity at Coarse Gold, Madera County, California, as well as in many other California localities. You seldom see any axinites from California today, except for a surprising find made during the digging of the New Melones Dam in Calaveras County.

While blasting to form a spillway, several pockets rich in axinite specimens were opened. The crystals have been proved to be ferroaxinites. There were actually veins of massive ferroaxinite and openings in which pockets of fine clove brown to violet-brown crystals formed. The finest Calaveras County crystals reached nearly 4 inches in length and are typically wedge shaped. Most are glassy and bright. Some of the crystals contained gemmy areas that cut into fine faceted gems. A number of knowledgeable collectors rank the New Melones Dam specimens among the very best ever found in America. Unfortunately, the area is now closed to collecting and, in fact, was closed before specimen collecting ceased.

Much farther south in Baja California, Mexico, a typical deposit of alpine-type minerals, including sphene and axinite, was found at Mina Oliva. It produced some interesting specimens, many coated with chlorite. Little exploration work has been done here in the last couple of decades.

The classic tin-copper district of Cornwall also produced some fine axinites a couple of centuries ago. The better crystals came from vugs in the cliff walls of the Botallack Mine, which overlooks the Atlantic Ocean.

For the fluorescent collector, a wonderfully unusual type of manganaxinite was formerly found at the famous zinc-iron mine at Franklin, New Jersey. Known as the Fluorescent Mineral Capital of the World, Franklin has produced dozens of minerals that respond beautifully to ultraviolet excitation. They usually occur in pleasing mixtures and many of them owe their response to trace amounts of manganese.

The axinite from Franklin contains manganese as an integral part of its composition, so the mineral is manganaxinite. The vast majority of manganaxinite from Franklin is massive. What makes it special is that the manganese causes it to give a strong red response to short-wave ultraviolet light. Rarely, exceptionally fine crystallized specimens of Franklin axinite consist of small vugs lined with tiny honey-yellow blades. They are usually only a fraction of an inch long. These are very rare and are highly prized by collectors of Franklin, New Jersey minerals.

Specimens of the massive axinite material from Franklin are sometimes sold by fluorescent mineral dealers and collectors, but since the Franklin mine has been shut since 1954 and the very similar, nearby Sterling Hill mine does not produce axinite, chances of obtaining a specimen of this manganese-rich fluorescent axinite are not good.

Virtually all the zeolites and those species usually associated with them are silicates. One such is the mineral babingtonite. It is not a zeolite, but is frequently found in basalt and other zeolite environments. Babington, too, has more than one species, there is normal babingtonite and manganbabingtonite. You and I can't tell the difference, but the experts can.

Babingtonite is usually the name used for this hydrous calcium, iron, manganese silicate, but when the manganese exceeds the iron by a large margin, the mineral is considered manganbabingtonite. Oddly, while iron can substitute for manganese, the amount of iron in the mineral is apparently insufficient to invoke the obvious name ferrobabingtonite, as that isn't a recognized species.

Babingtonite occurs as dark green to nearly black, platy crystals in zeolite localities. The crystals tend to be small, sometimes hardly reaching ⅛ inch. The larger crystals can be ¼ inch or larger and are sometimes tightly clustered in subparallel arrangement. Scattered on green prehnite or a zeolite mineral, babingtonite is usually easy to recognize, as it is about the only black-looking mineral that occurs in zeolite deposits.

The better babingtonite locality in the United States is the Lane Quarry in Westfield, Massachusetts, a now closed basalt quarry. Fine crystals to an inch occurred here in quantity before and just after World War II. This is one quarry I thought I might collect, even though it was closed to collectors. I knew, ever so slightly, the CEO of the company that owned the quarry. But when I asked if I could collect, his answer was, "Hell, *I* can't even go in there!"

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On a recent visit to the East Coast Show in West Springfield, Massachusetts, I was shown several nice specimens of this mineral, which a fellow had put on display. He had them labeled as coming from the Lane Quarry and said they came out recently, so perhaps collecting there is possible under some conditions.

Since babingtonite occurs in basalt deposits, you would expect to see it with the zeolites from the several famous specimen quarries around Paterson and elsewhere in Northern New Jersey. It has occurred there, usually as little rosettes, but has never been anything but uncommon here.

The same may be said about the many basalt quarries in India. They have been yielding some of the world's finest zeolites and associated minerals in superb and vast quantities. So far, however, babingtonite is almost nonexistent here. Don't give up hope, though. Think of the amazing production of cavansite that suddenly occurred here in recent years. Quantities of this fine blue mineral are still being brought out.

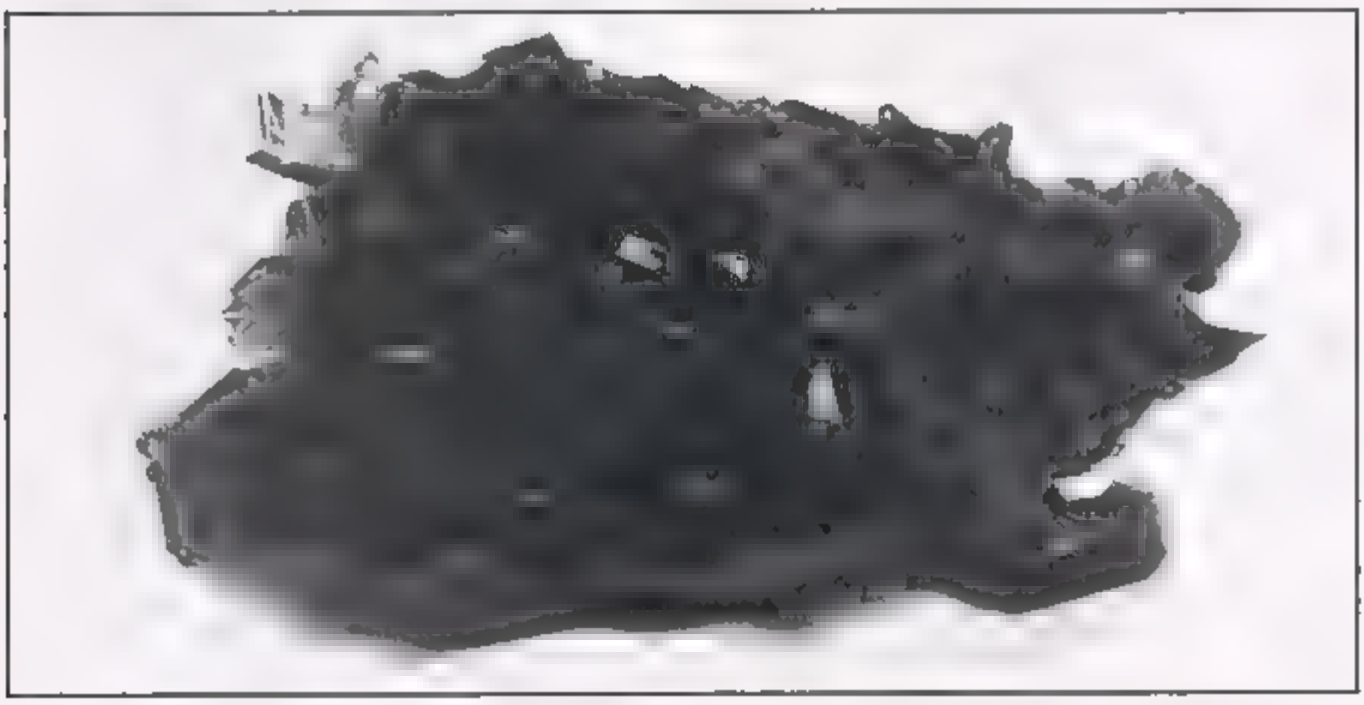
If it were not for one occurrence in San Benito County, California, I doubt the fine silicate mineral neptunite would be a collector mineral of note. True, it does occur at Mount St. Hilaire, Quebec, another really famous species source, but the site is far better known for choice serandite and a series of uncommon and rare species.

In the early days of mining on Greenland, the quarry at Narsarsuk, source of several rare species, was a good source of neptunite. When neptunite is mentioned, however, what immediately come to mind are the black, prismatic doubly terminated crystals found at the Gem Mine in San Benito County, California. Sometimes known as the Dallas Gem Mine, this unusual metamorphic deposit has produced California's official gem, benitoite. Along with that blue gem, it has produced some of the world's finest neptunites. Both minerals occur in natrolite seams. The natrolite provides a stark white background for bright blue benitoite and black, sharply crystallized neptunite. Along with the blue benitoite and black neptunite, you can often see tiny, bright, brown crystals of joaquinite, a very rare, complex cesium, barium, sodium, iron, titanium silicate.

The benitoite deposit was found by a prospector named Couch while he was looking for mercury deposits. Couch noticed a slope of white material. On close inspection, he found small, blue crystals scattered about on the white matrix. He thought he had found diamonds and hurried back to Coalinga. He showed them around and was advised to stake a claim. Couch had a man named Dallas, who had grubstaked him, file the claim for him. That is why the benitoite/neptunite Gem Mine was known early on as the Dallas Gem Mine.

The San Benito County neptunites are often doubly terminated and can reach well over 2 inches in length. They show a bright luster and, in thin section, are red-brown. In a square cross section, neptunite crystals often show a twist along their prismatic lengths and the crystals may show curving faces. Neptunites from the Gem Mine usually occur as individual crystals, and less often in tightly grouped clusters.

Without the California deposit, neptunite would be a rare breed indeed. It has come from Peru in large crystals, some of them to 4 inches long. These tend to be rather dull and their faces are sometimes deeply etched and coated with a brownish iron mineral. While these crystals are sometimes longer than the San Benito crystals, they are never as attractive.



Crystals of axinite have been found at the Dodo Mine near Puiyva in Russia's Polar Urals.

Another fine silicate mineral found in zeolite localities is datolite. While not a zeolite, this fine calcium hydroxyl boro silicate is found abundantly in several basaltic zeolite deposits associated with prehnite and many zeolites. An excellent collector mineral, glassy datolite occurs in gemmy crystals that show a multitude of faces. It is one of the more difficult crystals to orient properly because of the complexity of its faces. It is a monoclinic mineral, but any amateur is hard pressed to get a single crystal oriented properly.

Datolite is usually a shade of green, but can range from colorless to faintly green to an intense light to medium green. The darker green crystals have come mainly from the species-prolific, boron-rich locality at Dal'Negorsk. In fact, it is the most common boron mineral found at Dal'Negorsk and is even mined as an ore at the deposit.

Datolite is found in varying amounts in almost all basalt trap rock quarries in America. Certainly, the New Jersey deposits have produced plenty of collector specimens. Their crystals tend to be under 1 inch, though some 2-inch crystals have been found. Again, as this region has no accessible quarries today, anything from here is old stock.

The Lane Quarry in Westfield was also a good source of datolite, with plates of 1-inch crystals found lining open seams during quarry operations. Again, general collecting here is not allowed.

Certainly, my favorite source of datolite was the Roncari Quarry in East Granby, Connecticut. Years ago, when the quarry was active and accessible, I was lucky enough to get to know a quarry foreman who loved to collect. He took me into the quarry a couple of times and we successfully collected datolite in small plates and clusters. The crystals were often very gemmy, pale green, and very lustrous. I never did collect from some of the huge, open seams my friend had described to me back in the 1950s. It was from these that he did most of his collecting during mining operations. He told me he used to drive his station wagon into the quarry after work hours and back it up to large, open vugs exposed during blasting. He could actually walk into these open gashes and, using a crow bar and hammer, peel huge plates of datolite off the walls. I knew he was telling the truth because, on my visits to his home, I saw quantities of large datolite plates. In particular, I always admired the 3 foot wide plate of gorgeous datolite crystals hanging over his mantle. In his cellar were boxes and boxes of fine zeolites, including lovely datolites, prehnites, barites, and calcites. Many of the Roncari Quarry datolites are 2 inches or longer and very gemmy.

In one of the sadder stories of greedy collecting, my friend was finally prohibited from collecting any more at the Roncari because a major customer of the quarry, also a mineral collector, gave the quarry owner an ultimatum. He said he would take his business elsewhere unless he could have exclusive collecting rights in the quarry! Ironically, the upper basalt zone, which normally contains the majority of large, mineral-lined pockets in basalt quarries, had been mined out, and the greedy businessman managed only a few decent collecting events.

The famous silver mine at Guanajuato, Mexico, has certainly produced some fine datolites, though none lately. Its best crystals were 3 inches across, pale green and gemmy. Another Mexican mining region, also noted for fine collector species, is Charcas, San Luis Potosi. Here, datolite crystals up to 3 inches across came to light during mining. On rare occasions, one of these specimens will surface at a show.

Finally, in the copper mines on the Keweenaw Peninsula of Michigan, world famous for its native copper and silver, small, choice, solid nodules of datolite are sometimes encountered. When cut open, these nodules reveal a white, porcelaneous interior often beautifully tinted with suspended microscopic crystals of copper.

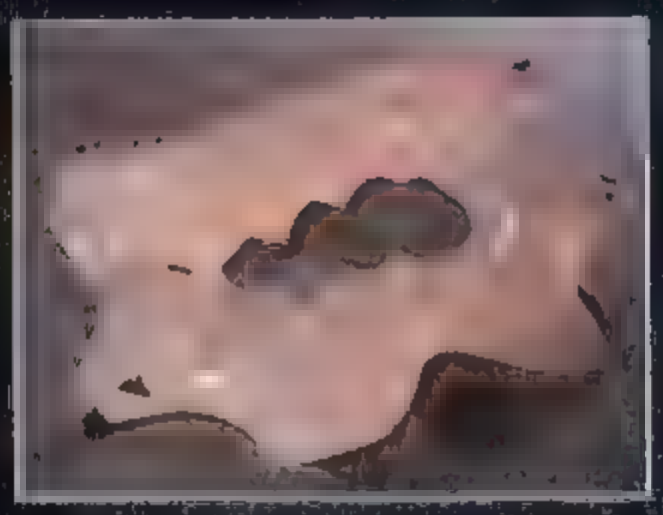
The copper in most of these nodules, which can sometimes reach a foot across, is usually concentrated along the perimeter of the nodules. In the finer nodules, the copper is diffused throughout, giving the entire nodule a very attractive rusty red hue. The hardness of this material runs between Mohs 5 and Mohs 6, so the nodules can be polished to a reasonable luster. Now that these mines are shut down, the only datolite nodules that come to light are found while digging in the dumps of the old shafts. These same dumps are also being diligently scanned with metal detectors in search of native metals. The results have been rewarding at times, as nice specimens of native copper and, less often, choice crystalized native silver are detected.

We have barely touched the silicate group of minerals so far. In Part II, I will describe several important collector silicates, including danburite, titanite, benitoite, brazilianite, and one of my favorites, epidote.

Beyond Cabbing

Freeform Agate Carving Gives Freedom of Choice

Story and Photos by Tom Harmon



Some 70 million years ago, catastrophic crustal events on the Earth's surface brought the huge creatures that roamed the planet to their knees. This may not have been the event that brought them to extinction, but it definitely had an impact on their lives. This event was so devastating that the Earth ripped and wrinkled as two continental plates – the Pacific Plate to the west and the North American Plate to the east – ground together. New mountains and valleys were formed, and living things were buried under mountains of lava and ash. Forests of mighty redwoods trembled and fell in the path of hot lava, gas and ash. As life on this planet changed forever for some species, new possibilities began for other forms of life, and even in death new things were brought to life. A change began in the huge trees now buried under the foreboding new landscape.

As the Earth began to cool and water once again began to flow across the surface of the land, the landscape changed. New-formed mountains grew and more lava flowed from the cracks and rips in the Earth's crust. After a time, the land grew silent and many new and changed forms of life began to emerge. As live things changed, things that had once been alive also changed in form and function.

The cooled lava was a source of silica. Water began to break down the lava into its basic elements. The silica-laden water began to flow into the pockets and voids left by the decomposing trees and babbling lava. In repeating cycles of filling and evaporation, a new type of rock formed in the pockets. We now call this form of rock chalcedony, and if it forms in a certain way, it is an agate.

The conditions for agate formation were in place during the major, catastrophic volcanic activity that began to form the Rocky Mountains. The Pacific and North American plates came together, causing a multitude of wrinkles in the landscape that became the Continental Divide and the Rocky Mountains. Agate formation began in the lava beds formed on both sides of the huge geological wrinkles. To the north and west sides of the mountains, agates of many types were formed in what is now Oregon, Washington and Idaho. On the east side of the Rockies, far to the north in Canada, Montana agate was being formed, and many miles to the south in what was to become Montana and Wyoming, the conditions to make Montana agate were present in the lava beds of the Absorka volcanoes. Continental crust events that followed many millions of years later broke up the lava beds that held the agates and eroded them into the gravel beds in which the agates are found today.

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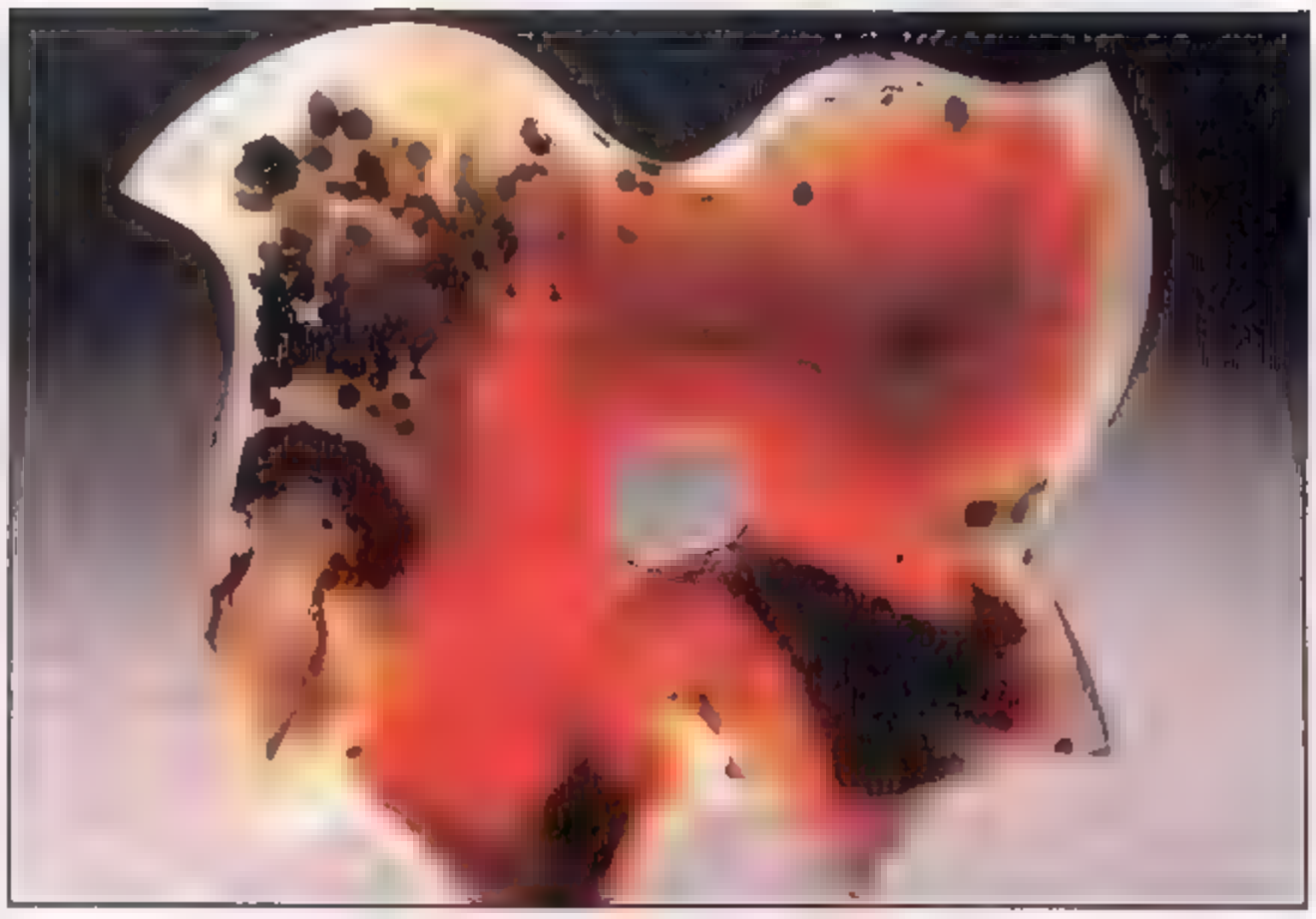

The patterns and colors of this small, thin agate were lightly hidden under the outside crust, which I ground away to expose "The Lady in the Pansy."

This agate slab showed so many scenes and pictures that I tried to save them all in a flowing shape I call "Lake by the Fire."

This slab of agate had a natural hole in the middle, which I just expanded on with a hand-held Dremel tool.

Beyond Cabbing *from page 29*

Montana agate is found in a large area of Eastern Montana in the Yellowstone River Valley. The main exposure of the Flaxville gravel vein, in which the agates are found, runs from about Custer, Montana, to the confluence of the Yellowstone and Missouri rivers at Ft Union and Ft. Buford, close to the Montana-North Dakota border Montana agate can be found farther west up the Yellowstone River Valley beyond Custer to Livingston, but in lesser quantities. Many of the agates were brought into the Yellowstone River Valley when the Flaxville gravels were being laid down via the Big Horn, Tongue and Powder rivers, which drain the Big Horn Mountains in Wyoming. This is a major reason much more agate is found below the mouth of the Big Horn River, which comes into the Yellowstone River close to Custer.

The Native Americans who lived in what is now Eastern Montana or Western Dakota were the first to work Montana agate into objects of beauty or tools. In the early 1900s, the first white settlers and homesteaders began picking up the agates that they found lying in the creek beds and river bottoms where the Flaxville gravels were exposed The first serious work done to turn the agates into jewelry and adornments began in about 1914.

As rock-cutting equipment began to improve and became available to novice lapidaries in the 1940s through 1980s, the rock hobby grew into the hobby of choice for many. Great diamond equipment is available to the hobbyist of today, maintaining the hobby's popularity for the entire family

The first thing a new lapidary novice will probably do is cut and polish a rock specimen or cut and finish a slab into a cabochon. This may be as far as some lapidaries will want to go, but others might want to take it a little farther

Freeform lapidary carving is a process that goes a little beyond cabbing by adding another dimension to the look of a finished piece, but still gives a freedom of choice in shape and depth. Carving rock into objects like frogs or fish involves most of the same procedures and steps, but requires much greater discipline to produce a lifelike image. Freeform carving gives you the freedom to go with the flow of the stone or any shape that you feel is right

Freeform carving in a semitransparent or translucent stone like agate is a challenging, but very rewarding, experience. The hardness of agate (Mohs 6 5 to 7) makes grinding, shaping and polishing it labor intensive, but it also lends strength and durability in the finished product.

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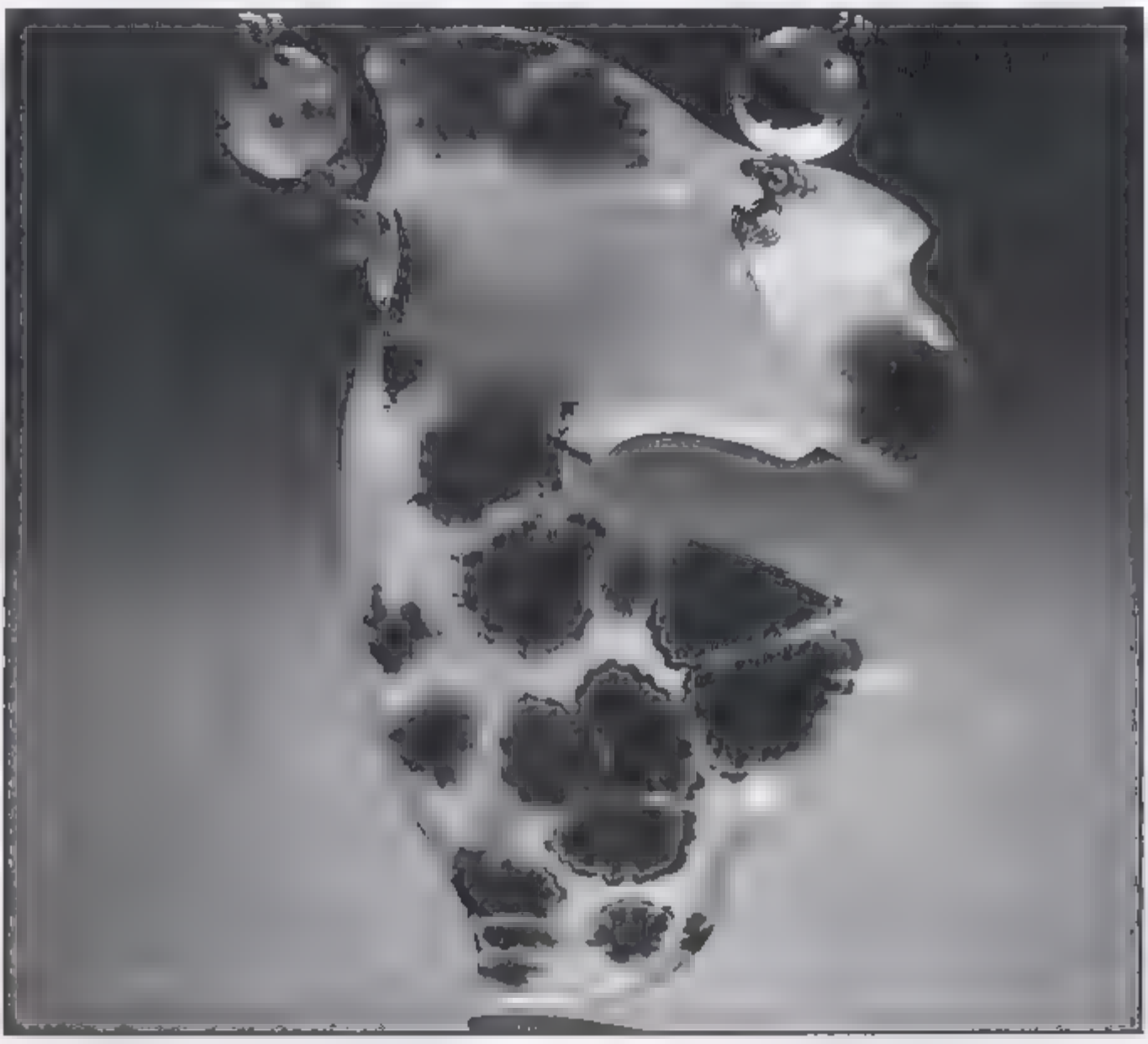


In this carved pendant, I ground a hole for the agate bead necklace to pass through.

Beyond Cabbing *from page 30*

Many beautiful agates are found in a multitude of deposits around the world, with each type unique to its deposit. Every agate is different, no two have the same pattern. The inclusions and patterns within each agate make them a natural material for freeform carving. Many times, just looking at a particular agate's inclusions and pattern will pull you in a specific direction of carving to further expose and expand the beauty within it. Whether the agate shows dendritic and scenic or geometric or concentric pattern lines of different colors, it will tend to pull you in a certain direction for cutting and carving. I carve mostly Montana agate. Living in the heart of Montana agate country gives me a little advantage in having access to a great carving agate deposit.

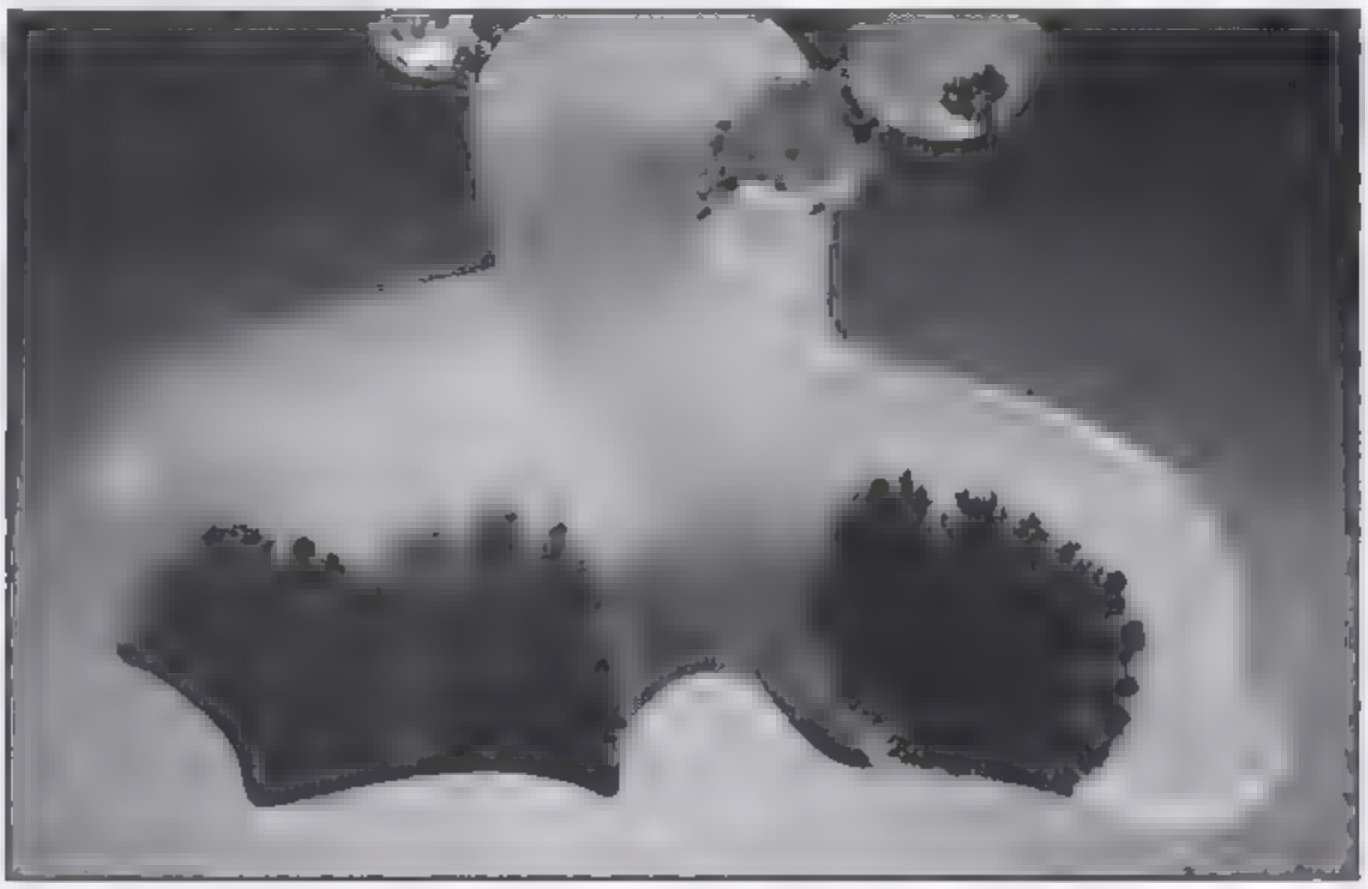
When carving, you want to expose the patterns within the agate to best advantage. Agates with the clarity of Montana agate are a little easier to read than some of the less translucent or semi-opaque agates. Both the pattern and any flaws will show up under a good light source, and this can aid in determining the overall shape of a carving. Amazingly enough, flaws in strategic areas on a stone can actually lead to a more interesting carving. If a block of well-patterned agate is flawless, one is a little apprehensive about cutting away areas of quality agate. In stones with some flaws (almost all do have some), new shapes and designs can be discovered in the process of eliminating the flaws.

The shapes and designs of the finished carvings will also be somewhat determined by the shapes and designs of the tools you are working with. If a specific curve or shape is desired, then you will have to find the correct tool to do that specific job. Many times, it becomes a compromise between the complete possibilities of the stone involved and the possibilities of the tool in hand. Thankfully, the tool needed to complete the job desired can usually be purchased or can be built from scratch. The stone, on the other hand, usually has its limitations, but with a little imagination, these can sometimes be stretched considerably. A certain shape or look can usually be accomplished with a little persistence. To make this process a little easier, choosing the best piece of rough to start with is quite important. That initial choice can mean the difference between an average-looking carving and a spectacular-looking one.

The actual working of the stone can be and is done by many different methods. The tools of the lapidary have been quite improved and have become more available in recent years, thus, the process has become a little more pleasant and fun, not quite as messy and noisy. I believe a big part of the fun and satisfaction in freeform carving is in taking a somewhat pretty agate and turning it into a thing of real beauty and being the first one to see it happen.

Each lapidary artist will determine the shape and nature of that beauty in his own eye, and this is one of the intriguing things about freeform lapidary carving. If you are looking for a fun hobby that almost anyone can do with a little practice and practical experience, maybe this is for you.

Tom Harmon and his son Jim Harmon are co-authors of Cabbing and Carving Montana Agate and Other Chalcedonys *which is advertised on page 52.*



This agate had large dendrites at different levels in the slab, so a shape to join the two levels was needed.

GOLD AND GEM HIGHWAYS

ROADSIDE PANNING SITES IN UTAH

Part II: Salt Lake, San Juan, Sevier, Uinta, Utah, Washington, and Wayne Counties

Story and Maps
by David and Clois Walker

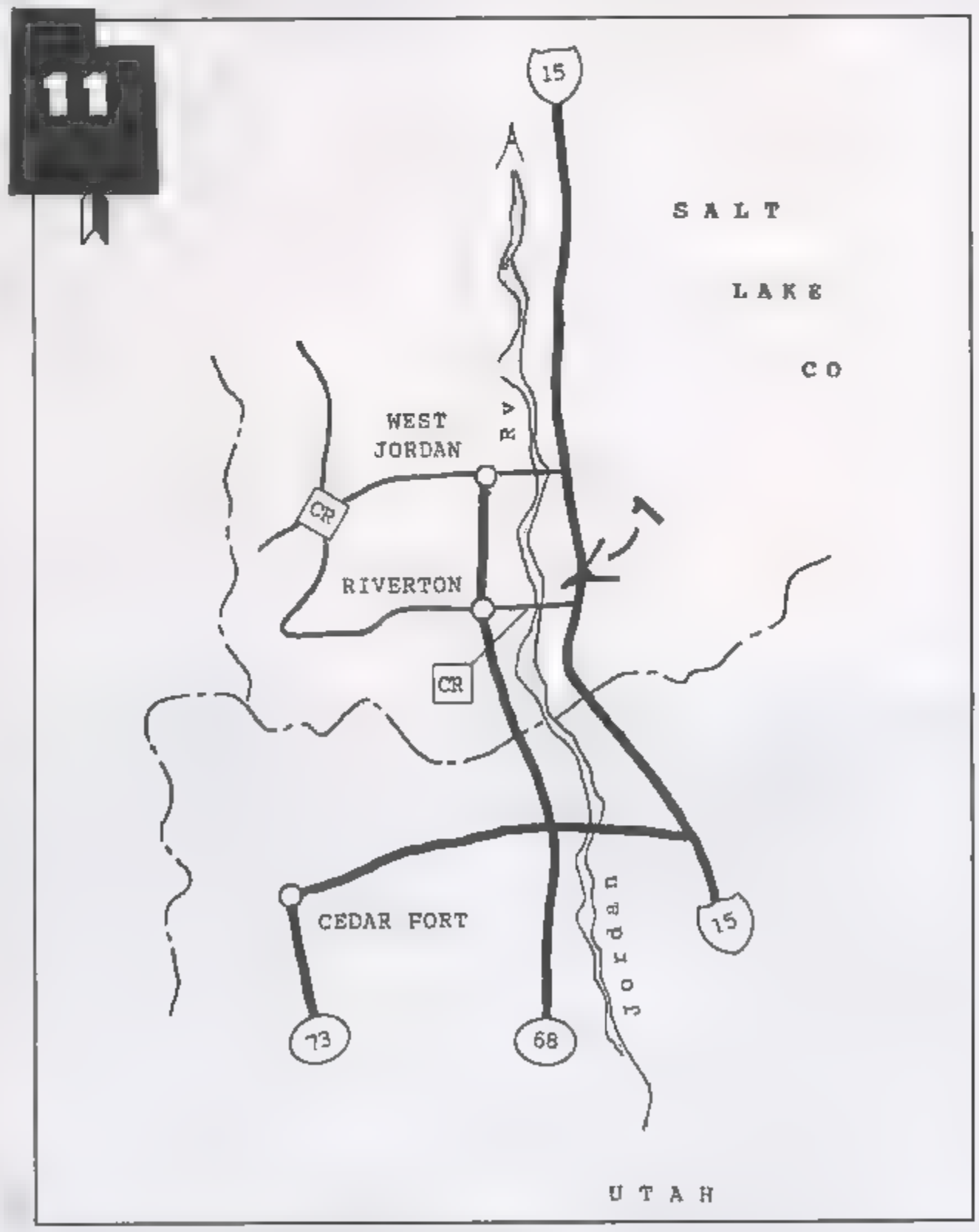
This is the second in a series of two articles containing county-by-county maps to suggested panning and screening sites at Utah highway stream crossings where appreciable finds have been previously reported in vicinity watersheds. The principles of erosion make it likely that minerals and gemstones have been deposited in river gravels, awaiting removal by a rockhound with a pan.

By confining operations within government-purchased highway rights of way, panners are spared the necessity of locating and obtaining permission from adjoining property owners, including state and national parks and Indian reservations. However, readers run the risk of prosecution if they cross onto private land, whether purposely or inadvertently. In instances where rights of way have merely been leased, other rules may apply.

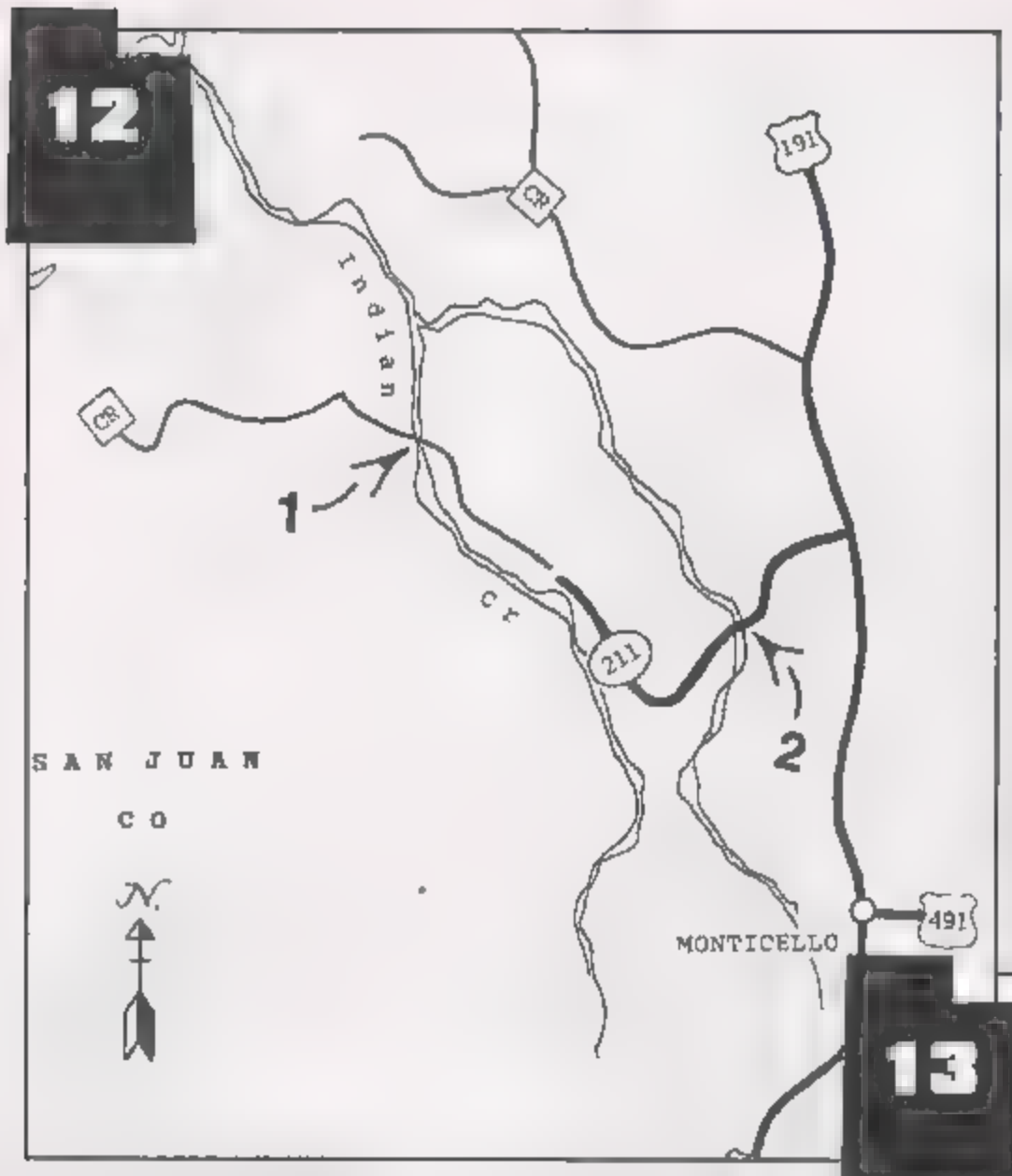
Utah welcomes tourists, but requires permits for panning—a separate permit for each of four sections of the state. To obtain permits and for an explanation of the boundaries of rights of way, call Becky at (801) 965-4000 *before* you visit these sites.

Remember that the government to which these rights of way belong has some regulations of its own. Observe highway safety and environmental standards, such as parking only where designated, and using only a pan and scoop.

The maps provided contain the most up-to-date information available to us, but it is advisable to consult a current state highway or county map when planning an outing, for overall orientation in the field and because highway designations have been known to change.



SALT LAKE COUNTY (MAP UT11)
Site 1. **Jordan River/County Road** crossing near **Riverton.** Vicinity finds include gold and malachite.



SAN JUAN COUNTY
(MAPS UT12-13)

Site 1 **Indian Creek/County Road** crossing near **Monticello.** Vicinity finds include garnet and gold

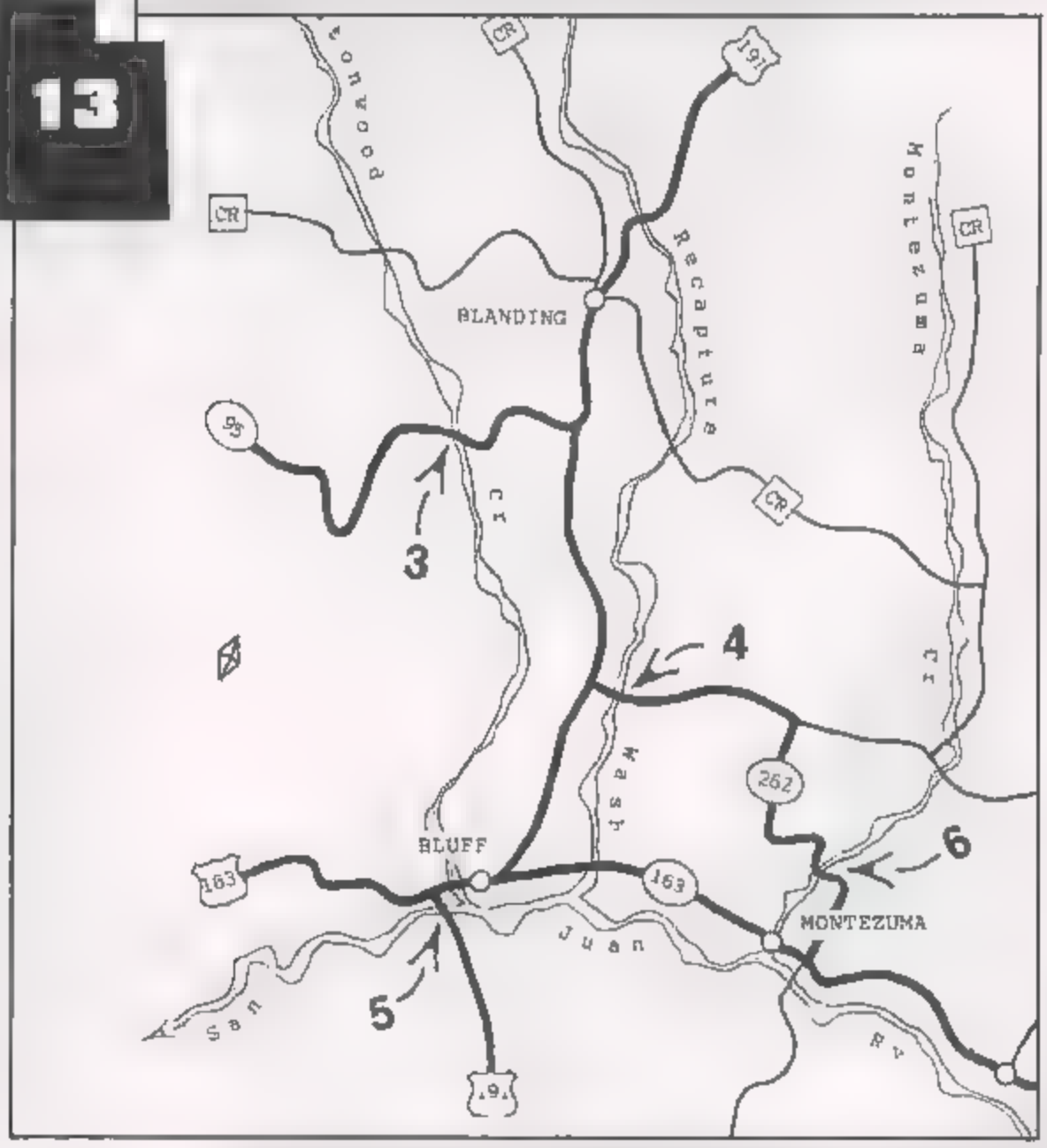
Site 2 **Tributary Indian Creek/state Route 211** crossing near **Monticello.** Vicinity finds include garnet and gold

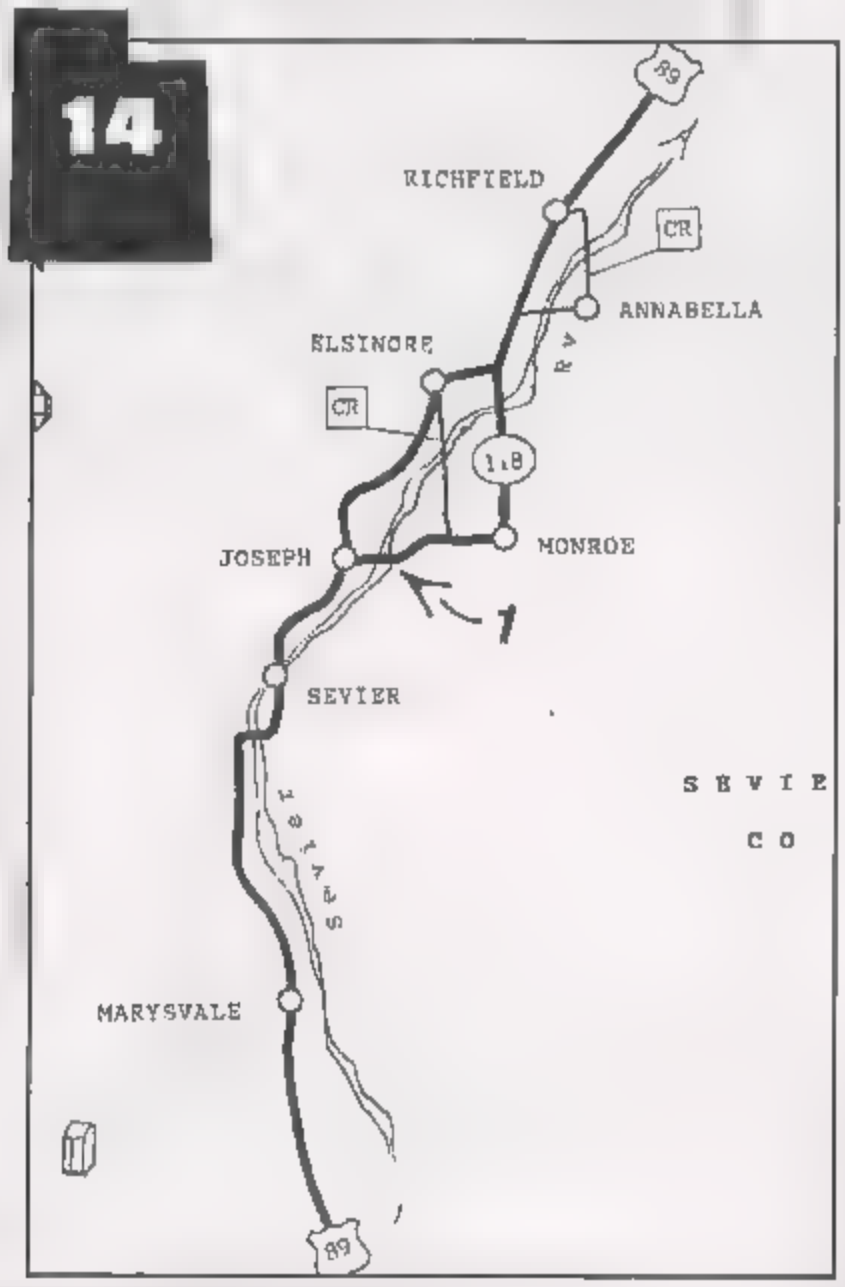
Site 3 **Cottonwood Creek/state Route 95** crossing near **Blanding.** Vicinity finds include agate and jasper

Site 4. **Recapture Wash/state Route 262** crossing near **Bluff.** Vicinity finds include garnet and gold.

Site 5 **San Juan River/U.S. Highway 191** crossing near **Bluff.** Vicinity finds include agate and gold.

Site 6. **Montezuma Creek/state Route 262** crossing near **Montezuma.** Vicinity finds include agate and gold





SEVIER COUNTY (MAP UT14)

Site 1 **Sevier River/state Route 118** crossing near **Joseph.** Vicinity finds include cinnabar and gold

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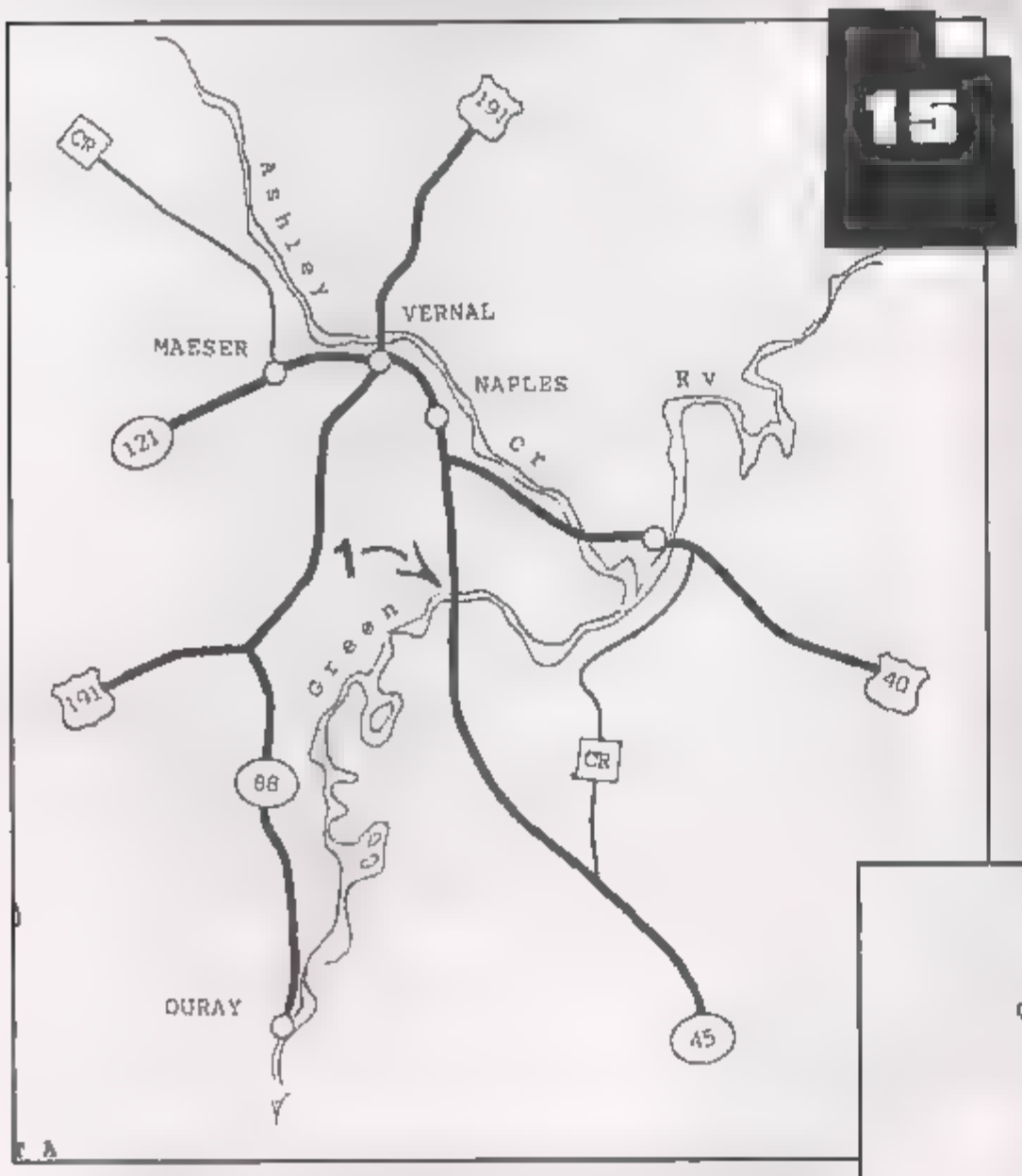
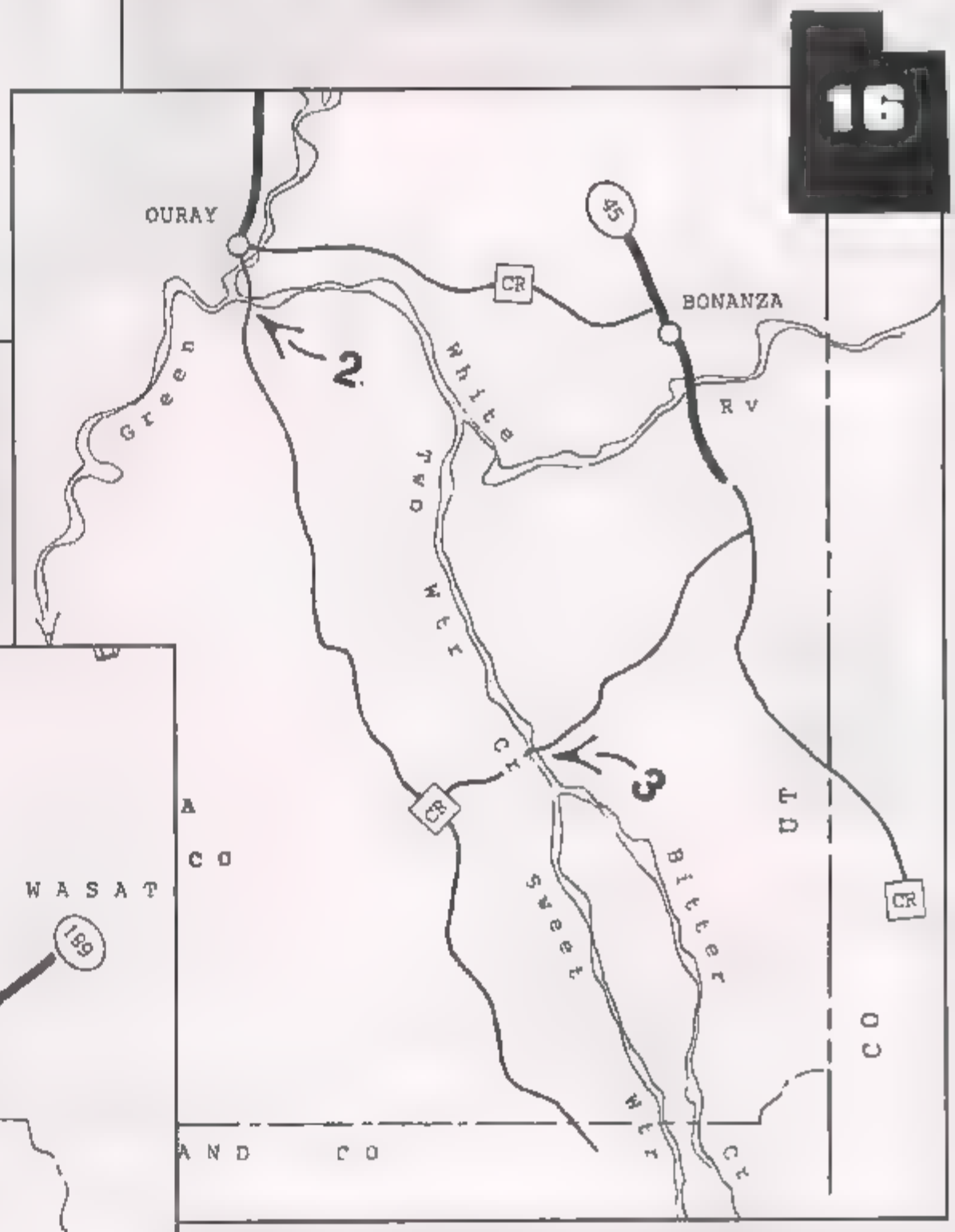


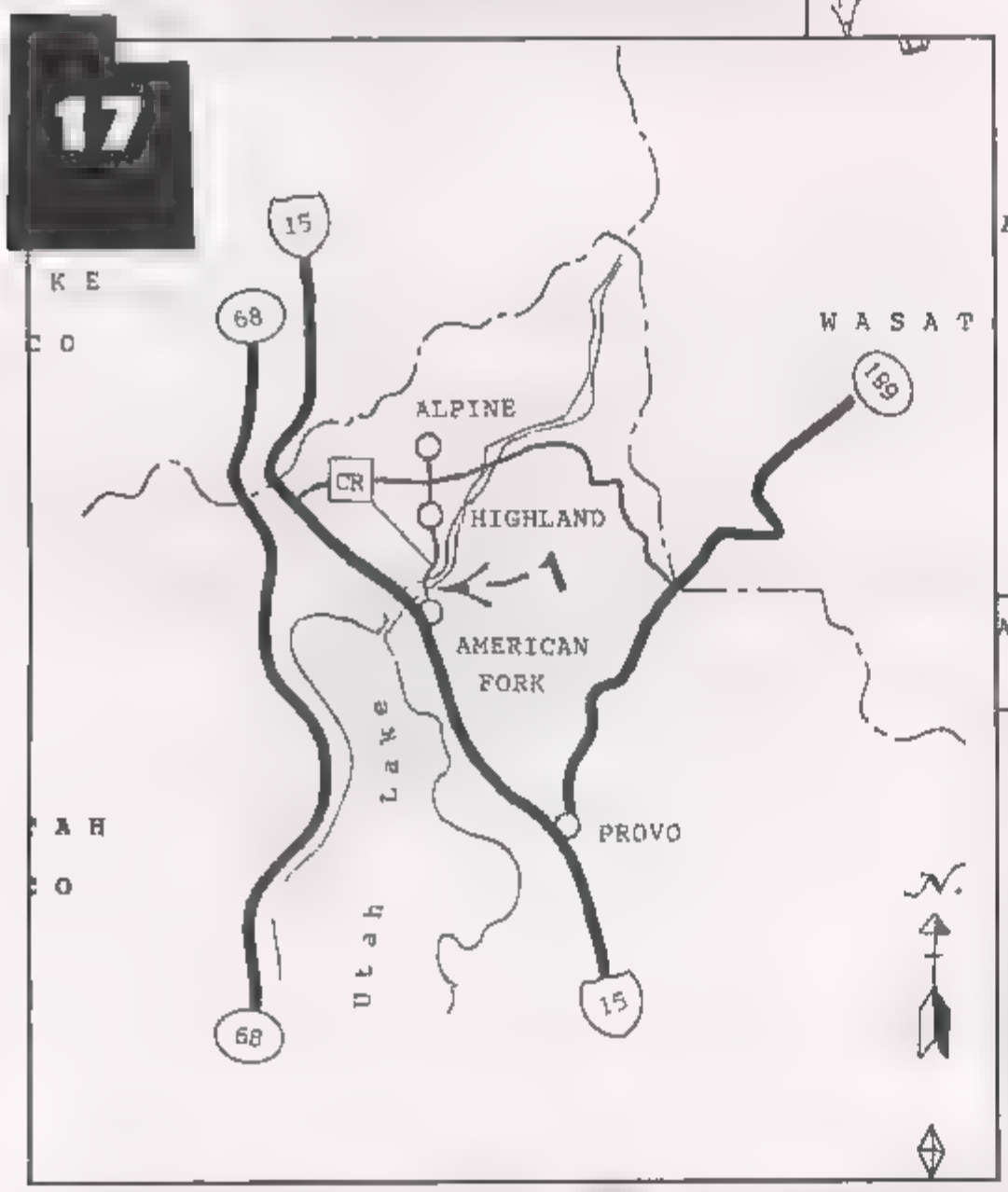
UINTA COUNTY (MAPS UT15-16)

Site 1. **Green River/state Route 45** crossing near **Naples.** Vicinity finds indicate gold potential

Site 2. **White River/County Road** crossing near **Ouray.** Vicinity finds include agate, chalcedony, jasper, and silicified wood

Site 3. **Two Water Creek/County Road** crossing near **Ouray.** Vicinity finds include agate, chalcedony, quartz crystals, and silicified wood.





UTAH COUNTY (MAP UT17)

Site 1. **Inlet Utah Lake/Interstate 15** crossing near **American Fork.** Vicinity finds indicate onyx potential

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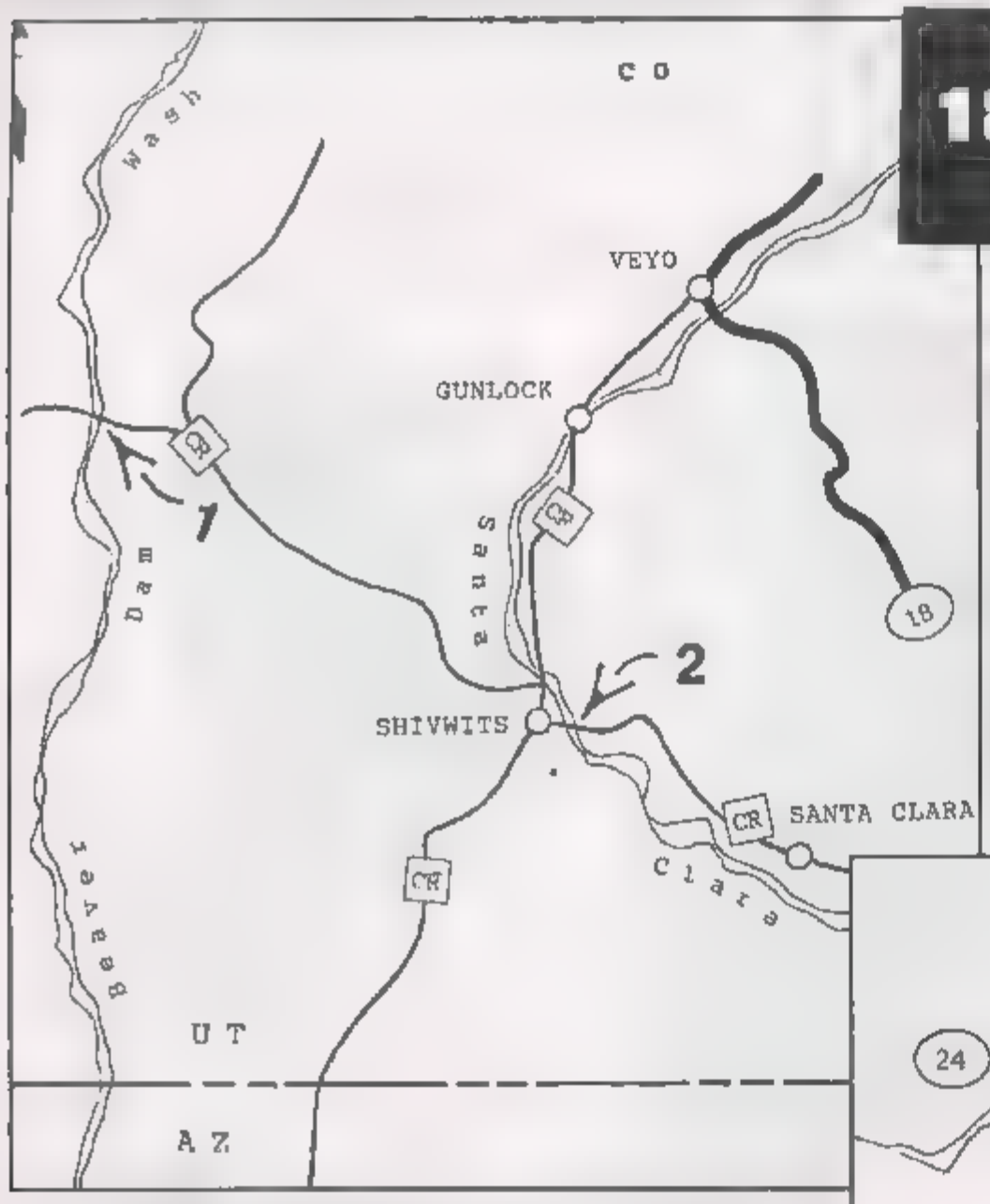
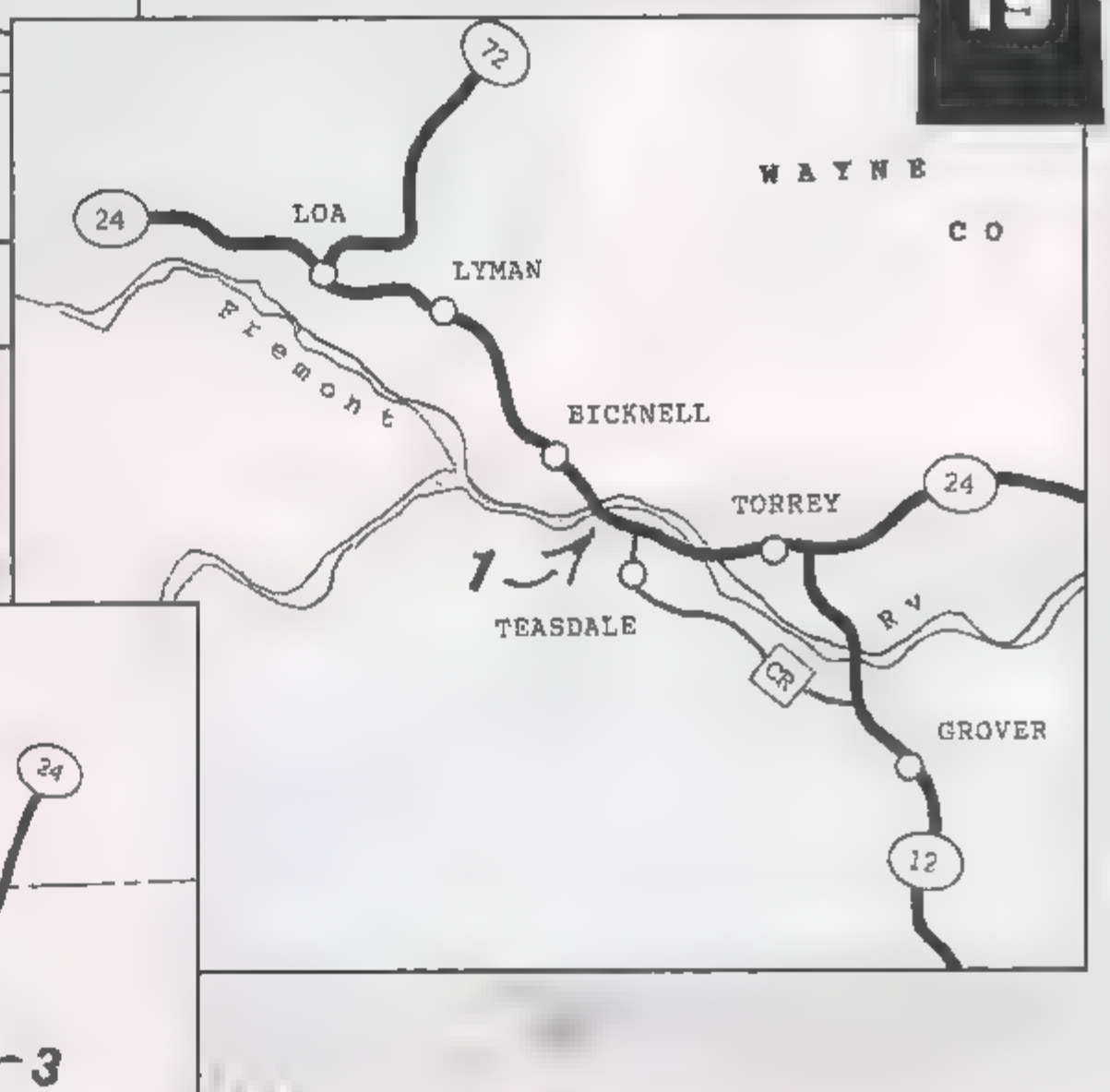
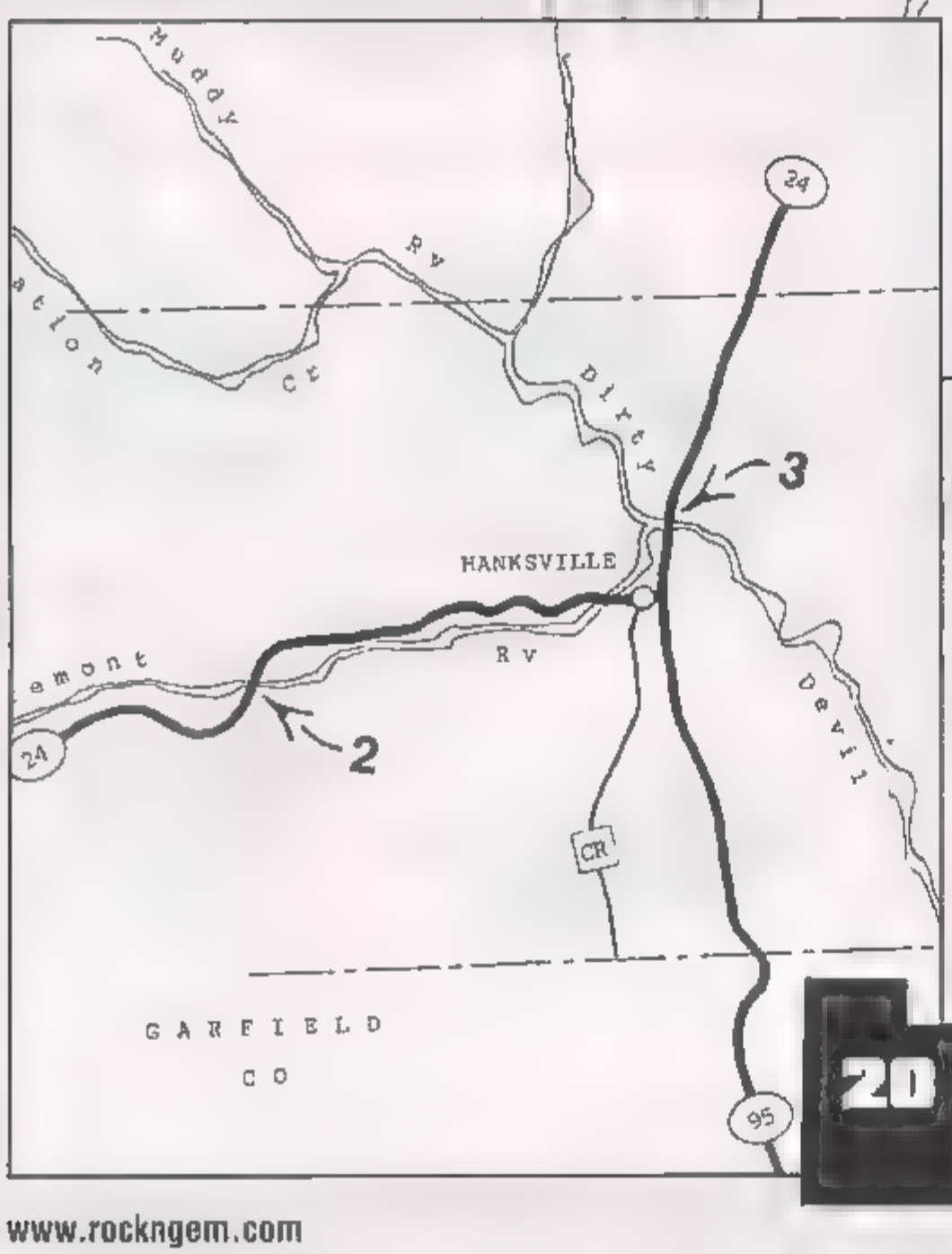


WASHINGTON COUNTY (MAP UT18)
Site 1. **Beaver Dam Wash/County Road** crossing near **Shivwits.** Vicinity finds include agate and jasper.
Site 2. **Santa Clara River/County Road** crossing near **Shivwits.** Vicinity finds include agate, chalcedony and jasper.



WAYNE COUNTY
(MAPS UT19-20)
Site 1. **Fremont River/state Route 24** crossing near **Bicknell.** Vicinity finds include agate and jasper.



Site 2. **Fremont River/state Route 24** crossing near **Hanksville.** Vicinity finds include agate, jasper, and silicified wood.
Site 3. **Dirty Devil River/state Route 24** crossing near **Hanksville.** Vicinity finds include agate and silicified wood.

FIELD TRIP

DOGTOOTH MERCENARIA

Collecting Calcite-Filled Clams at Rucks' Pit, Florida

Story and Photos by Everett Harrington

Rucks Pit, in Okeechobee County, Florida, is a source of Mercenaria clams filled with golden calcite crystals

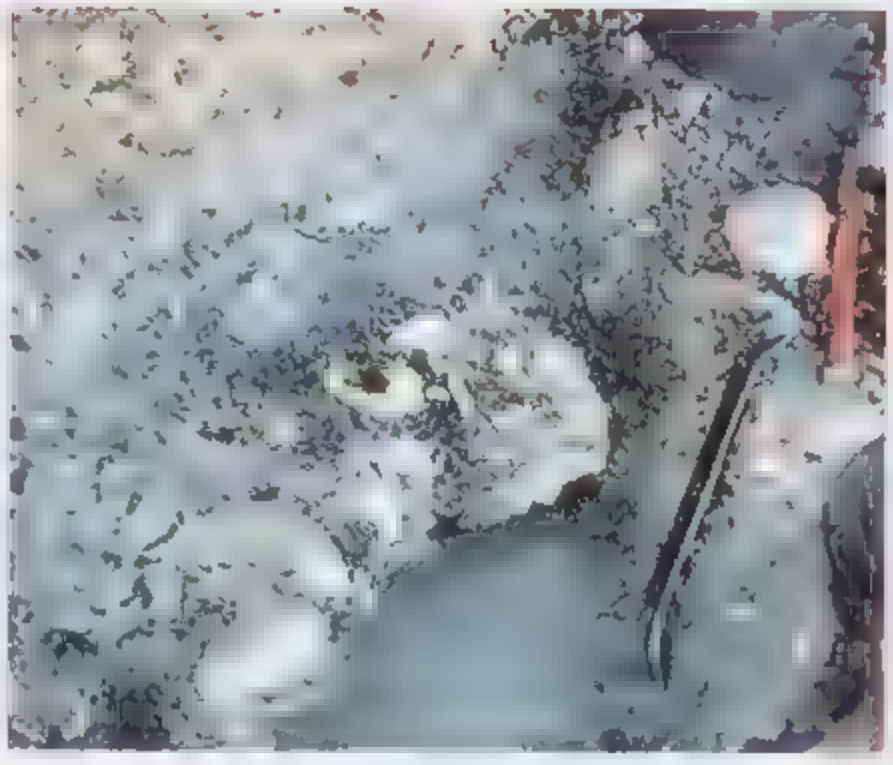
As I stepped off the plane, I felt the 70-degree Florida wind blowing on my face. I thought about how I had been feeling five hours before in subfreezing weather back home in Michigan. I had flown 1,500 miles for this extraordinary opportunity on a two-day dig. I was on my way to Rucks' Pit, near Ft. Drum, Florida, to collect the now-famous Mercenaria clams filled with exceedingly lustrous golden calcite crystals.

Matrix pieces of Mercenaria clams are hard to get out whole because of the fragile nature of the Nashua limestone.

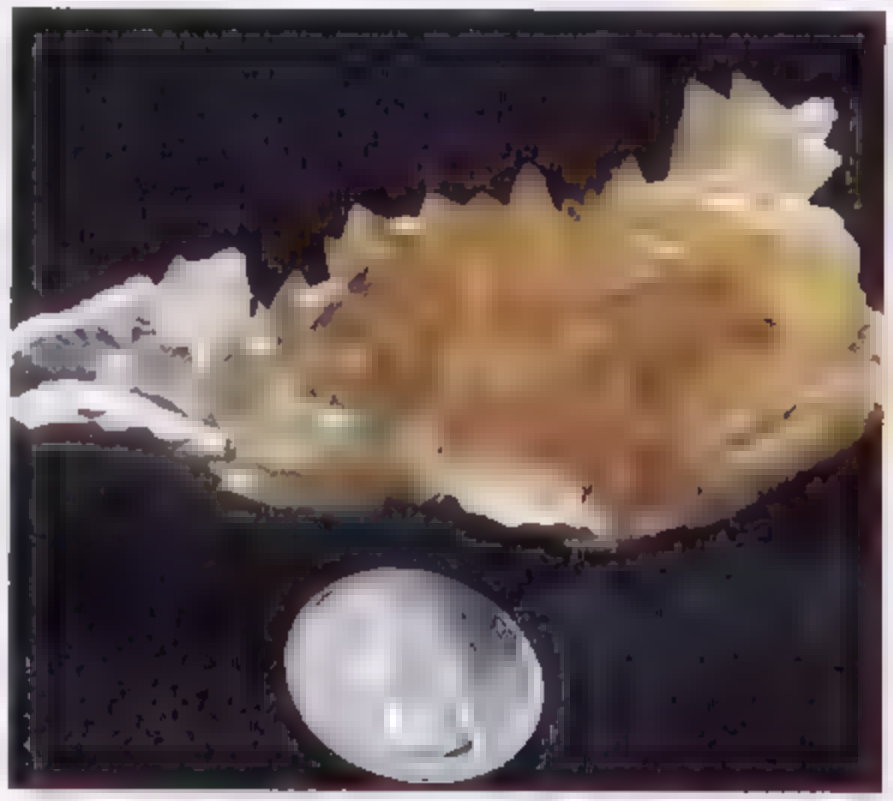
Rucks' Pit, in Okeechobee County, started out as a shell pit in the 1950s. Shells were mined and ground up to make gravel for roads. The shells are ideal for this usage because of the cementing properties of the calcium that comprises them. The mining continued, and around 1987, a vuggy limestone rock was found deeper in the pit. This limestone also made a great road aggregate. Until three years ago, the miners used explosives to mine the rock from Rucks'. As they moved more towards mechanical means of extraction, they stopped using these explosives. Now that the explosives are not disintegrating the rock, the miners started to find the now vastly collectible Mercenaria clams bursting with beautiful dogtooth calcites. Later examinations of the sands found in the shell pit confirm a 3 percent titanium content, which is just shy of the 5 percent needed to mine this mineral commercially.

The Ft. Drum mine, branded Rucks' Pit, is within the Kissimmee Valley. Because it is so near sea level, this area has dried out and flooded quite a few times over the past 3 million years. This cycle has created at least six different shell beds in the three geological formations found at Rucks'. The uppermost Ft. Thompson formation (75,000 to 150,000 years old) is composed of a red sand/peat, in which such shells as the Florida crown conch can be found. The species found in this part of the stratigraphic column are still found living in the southern Florida seas today.

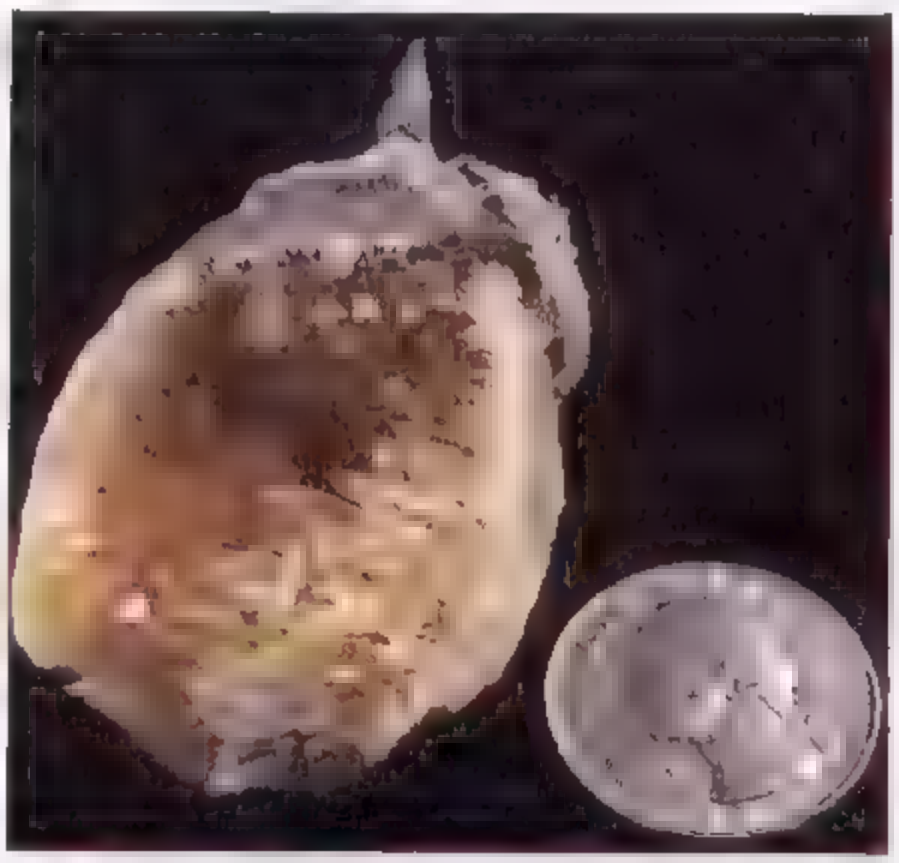
Beneath the Ft. Thompson structure is the Nashua (1.8 million to 2 million years old). This layer is subdivided into three distinct sublayers. The top sublayer is mostly a white, sandy lime mud, in which there are profuse oyster and Sun scallop shells. Next is the Rucks' Pit member of the Nashua (2.3 million to 1.6 million years old). It is a very dark-gray limestone. In this you will find the Mercenaria and Busycon shells filled with the awe-inspiring calcites. The lowest subdivision is a compacted layer of Mercenaria clams in which there is an artesian flow of water due to the permeability of the bed of shells.



Free-flowing water in the pit floor can be used to wash off the pockets of Mercenaria clams.



Iron impurities cause the calcites found in the clams to be a golden yellow color.



Even if clams end up broken, the nice calcite clusters are still collectible items.

The last formation found in the deepest parts of Rucks' Pit is the Tamiami (2.6 million to 3 million years old). Of special interest in this formation are the cowry shells; 13 different species are found here. As more people search and dig in Rucks', there are sure to be more new cowry species discoveries.

For mineralogists and rock hounds, the most sought-after prizes from Rucks' would have to be the Mercenaria permagna Venus clams found in the Nashua formation. These wonders of the mineral world had a five-step diagenetic process of formation. In the initial stage, an extensive tidal flat of mud and sand housed countless quantities of Mercenaria clams. Next, lowered sea levels exposed the clam beds to more frequent desiccated periods, which killed them off. Most were still in the "living position," with the hinge facing up. At this time, the clams were entombed in quartz sand mixed with organics. Throughout the lowered sea levels, a new stage of cementation began. Atmospheric water percolated down through the layers above the Mercenaria layer, dissolving the smaller, more delicate shells. This soon created a supersaturated solution of calcium carbonate, which bonded the sand and shells together. The solution that found its way into the Mercenaria, the hearty, thick-shelled clams that survived the dissolution, started to crystallize into the honey-yellow calcite crystals we collect today.

Following cementation, this area became a large freshwater marsh or lake. The silts full of organic material are what stained the limestone its identifiable gray color. The staining was caused by iron sulfides that form in the muck layers at the bottoms of these swamps and lakes. Further dissolution took place during this time and crystal growth continued. Finally, rising sea levels around 1.9 million years ago washed over the area, scrubbing it of all the sulfide production. The perfect golden calcites found today owe their coloring to the iron atoms from the sulfides which bonded within the calcium carbonate crystal lattice.

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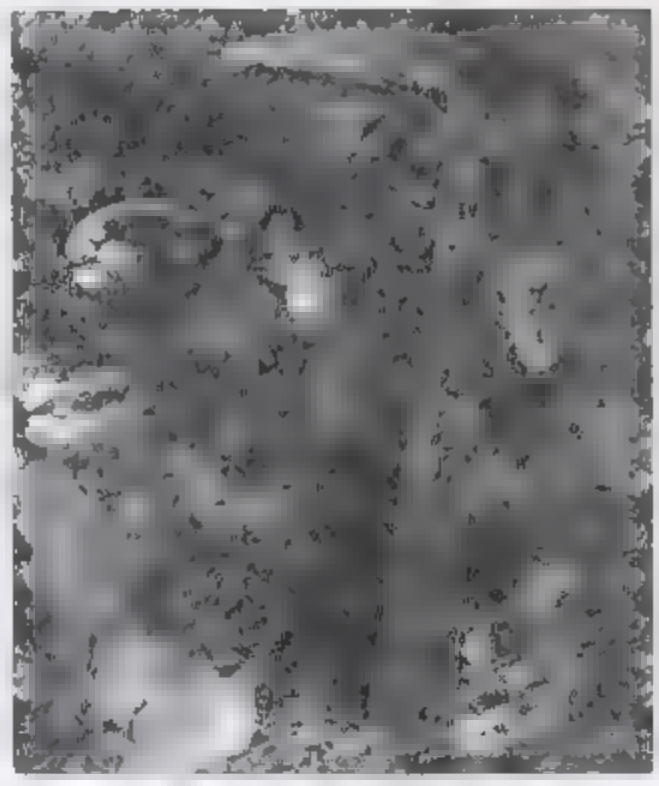
Calcite, found within the Mercenaria clams, gets its name from "chalix," the Greek word for lime. This calcite forms in a scalenohedral crystal habit, or "dogtooth" spar, as it is occasionally called. Under short-wave ultraviolet light, these calcites show yellow to green fluorescent/phosphorescent reactions. Very gemmy calcite crystals are not uncommon once the proper dig locations are found.

My first day of collecting started out at the Ft. Drum General Store, where I met with my good friends Mickey Cecil and Gary Maddox. Considering that I had flown down, Gary was nice enough to let me use a set of tools he had brought for me. Mickey and Gary told me the initial place to start my search would be on the "spoil" piles that were drying out prior to being ground to make aggregates. Around 300 people had showed up for this open house, and it was pretty tough to find a good digging spot with that many collectors. What a splendid day it was for collecting. The sun put a warm touch on each of our faces as the temperature approached 70 degrees.

I started out by orientating myself in the very extensive diggings of Rucks' Pit. After scouting the ends of some 15 to 20 spoil piles, I decided to concentrate on the last five rows. To me, this looked like the most promising area. Not only was it farthest away from the parking area, but it also showed the most calcite. Peeking from the 10-foot-high piles were numerous possible treasures for the taking. Gary and Mickey joined me after a short time, and we all talked as we hunted. Sometimes, a shout was heard, and we all gathered at the finder's location to see what magnificent find was exciting him.

After spending most of the morning on the piles, we decided it was time to take a lunch break. We headed back up to the tents that were set up for the swap area and to a concession stand selling bottles of water and soda and BBQ sandwiches. We enjoyed a couple of the delicious sandwiches offered. With our bellies full, we decided to venture down to the main digging area in the south end of the pit.

I walked down into the pit and along the walls at the south end, looking into everybody's buckets like a fisherman strolling out to the end of a pier. Many of the people had been digging here since the first part of the day. Most had several very pretty single calcite-filled clams. I noticed that three others had breathtaking four- to six-clam matrix pieces, as well. I knew then that I wanted to find these matrix pieces, too. I searched and found Mickey.



The Mercenaria and Busycon shells filled with the awe-inspiring calcites are found in the dark-gray Nashua limestone.

Mickey and I started to scout for new locations for our next day's digging on Sunday. As we walked around, we heard a young lady asking for help. She and her two young boys were waist deep in the sand and mud in one of the drainage ditches that are in the floor of the pit. I started to look for rocks to stand on, making sure no other helpers were getting trapped. I handed Mickey a large chunk of limestone, and he threw it into the drainage ditch. We noticed that the water was only 3 or 4 inches deep. Now we were wondering how these unfortunate souls found themselves stuck in this sand/mud. Mickey jumped in and started to dig the woman out of the "quicksand." After two others joined in, we were able to free the worried parent. The two young boys came out shortly after. All in all, it was an hour-long extraction. Apparently, the mother had been trying to dig one son out, with the other youngster helping, and as they stood still in the same spot for a period of time, they, too, became victims of this quicksand. The rescued family continued to hunt clams right to the end of the day, minus their shoes, which will be found in a few million years filled with calcite crystals.

After this exertion, we decided to call it a day. It was late afternoon. We loaded up our precious finds, wrapping them very carefully in newspaper, and headed into Okeechobee for a steak at the Golden Corral.

Sunday was not so nice a day for hunting. It was noticeably cooler, around 60 degrees, and a light-to-heavy rain drizzled down on us. This was the day for the hearty collectors. Mickey and I decided to head down to the far side of the pit to a nice location that is not collected as much. The limestone here was much softer due to more weathering from the elements. Most of the Mercenaria found here are in the living position. Some of the crystals in these clams were reaching the top end of the size found here at Rucks', if you find any crystals over an inch, you have a prize specimen. As we worked, we were hit by more rain and wind. Now soaked to the bone, we had two buckets full of some of the finest clams to be found. We worked the area for approximately four hours, finding some great matrix pieces and some single clams, all with superb calcites in them.

Collecting at Rucks' Pit is both easy and difficult, depending on which method you decide to take. On the west end of the property, you can find substantial spoil piles upon which to hunt. They are dumped at this location to allow drying prior to the crushing/grinding procedure. Searching these piles, you are able to pick up single, loose Mercenaria clams with calcites. When hunting calcite clams, you will notice that if there is no calcite showing on the outer surface of the clam, there will not be any crystals inside it. It is very handy to have a bucket of water on the piles with which to clean any hopefuls of the sticky gray clay coating the crystals. Most of the already opened clams found on the spoil piles will show some dings and/or broken crystals. On occasion, it is possible to locate isolated matrix pieces here, as well. These, however, would rarely be found undamaged, as the machinery does an immense amount of damage to the larger pieces of rock found here.

On the south end of the active pit, you will find freshly exposed rock faces. Here, matrix pieces can be dug using a gad bar and a 3-pound sledge. One trick used in this area of the pit is to use a 5-gallon bucket to dip water from the many pockets of free-flowing water in the pit floor. Pour the water over your digging area to locate clams and clear off any mud or debris. It is especially important to check the fruits of your labors because the limestone of the Nashua formation is riddled with holes from the dissolved shells, making it very fragile. Matrix pieces are, beyond a doubt, the hardest thing to recover at Rucks'.

I did not bring enough newspaper. This is one of the most valuable collecting tools to bring. If you spend several hours chiseling and prying out a very nice matrix piece, you're going to want to make sure it is securely protected. Most people take several buckets, some for specimens and some for dipping water. Sunscreen is a necessity, even for cloudy days. You can burn very quickly under the Florida skies.

Cleaning your finds will prove more difficult than the actual extraction. Almost every clam will have very sticky clay in its cavities. I have found a long bristled paintbrush to be of great help. This will allow you to get into the nooks and crannies of your piece without damaging it. I used lukewarm tap water to make sure I didn't thermally shock my finds. Nothing would be worse than to have crystals break after working so hard to procure them.

The current owner of Rucks' Pit is Eddie Rucks. Rockhounds can collect by prior arrangement, and Eddie hosts open houses twice a year, when anyone can come to hunt. To make a collecting appointment, contact Eddie at 28320 N.E. 88 Ave., Okeechobee, FL 34972 or call (863) 634-4579.

To get to Rucks' from Interstate 95, exit 66 in Ft. Pierce. Take Orange Avenue west for 11.2 miles. Bear right on C.R.-68 (Orange Avenue) and continue west for an additional 5.7 miles. Turn north onto N.E. 48th Avenue (Hilolo Rd.) for 4.7 miles. Turn right (east) onto C.R.-15c (N.E. 304 Street), travel 1.2 miles, and you will see the sign for Rucks' Pit on your left.

Dr. Thomas M. Scott is the state geologist who, early on, was the first to realize the potential of this site. He, in turn, informed Edward Petuch and Gary Maddox of the extraordinary finds here in Rucks' Pit. Edward Petuch has written one of the best resources you can find about this wonderful location, a book called *Geology and Paleontology of the Fort Drum crystal mine, Okeechobee County, Florida*. This book covers the geologic overview and depositional history of Rucks' Pit. It includes a identification section of photographs containing 121 black-and-white plates of the different corals and shells that can be found at the pit. This book can be ordered for $26, including shipping, by writing to Eddie Rucks.

Because Rucks' Pit has exposed over 3 million years of ancient history, some 38 families of mollusks, including clams and snails, can be found there. These involve more than 70 different genera and in excess of a whopping 200 species. This area continues to be one of the most important geological, paleontological, and educational collecting locations in central Florida.

The future of collecting these fabulous calcite wonders looks very bleak. Inside the next two to three years, this pit will become an artificial lake just like its neighbor, Rucks' Lake. If you ever get the opportunity to visit Rucks' Pit, it will be well worth the trip. Happy hunting!

ROCK & GEM

Fluorite

The fulgurite shown in the July *Rock & Gem* Kids feature is on display in the Arizona Mining and Mineral Museum.

KIDS

by Sinkankas

Assemble a Hardness Testing Kit

How do you determine whether the yellow, crystalline mineral you have found is apatite or heliodor beryl? They both have hexagonal crystals and a yellow color. They may even be found in the same pegmatite.

One way to help determine the identity of a mineral is the "scratch" test. Some crystals are softer than others. If two minerals are rubbed against each other, the harder one will usually scratch the softer one. The Mohs Scale of Hardness was developed by Friedrich Mohs, who determined the relative hardness of some common minerals. The 10 minerals in the Mohs Scale are:

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Feldspar (orthoclase)
7. Quartz
8. Topaz
9. Corundum (sapphire or ruby)
10. Diamond

However, you really only need these three common items in your first hardness test kit:

- Fingernail (Mohs 2.5)
- Glass slide or jar (Mohs 5 or 6) (Any old piece of glass will do in the field!)
- Quartz crystal or agate (Mohs 7)

Here's why.

If your fingernail scratches the unknown mineral, it is soft like talc or gypsum (Mohs 1). If your fingernail can't scratch the mineral and the mineral can't scratch glass, then it is about as hard as calcite or fluorite (Mohs 3 or 4). If a mineral doesn't scratch glass very well and your quartz crystal scratches the mineral, it is probably about as hard as apatite (Mohs 5). If your mineral can barely scratch glass, but won't scratch your quartz crystal, it is probably about as hard as feldspar (Mohs 6).

If the unknown mineral you are testing scratches a quartz crystal, it's hard enough to be a gemstone like garnet, beryl, topaz, sapphire or diamond, so you should hold on to it and get some more information or learn some new tests!

Scratching the test kit items with our mineral specimen will cause less damage than scratching our specimen with the Mohs testing item. If you do choose to scratch your specimen, do it in a place where the scratch won't show, or in a broken or ugly place.

Specimen 1 will scratch your fingernail, but it doesn't scratch the glass slide or the quartz crystal. It is probably about 5 on the Mohs scale.

Specimen 2 scratches your fingernail, your glass slide, and your quartz crystal. It is at least 7.5 on the Mohs scale.

Since your specimens are hexagonal, the softer one is probably apatite, and the harder one is probably beryl, but it could also be a yellow sapphire. If a topaz crystal (Mohs 8) will not scratch the harder specimen, then it is probably sapphire. If topaz does scratch it, it is probably beryl (Mohs 7.5-8). Topaz and beryl are nearly the same hardness, so it may not be easy to scratch beryl with a topaz crystal. If you have a chrysoberyl crystal (Mohs 8.5) in your test kit, it should easily scratch the beryl, but won't scratch the sapphire. 💎

Rock & Gem Kids Quiz

The *Rock & Gem* Kids Quiz contest is open to U.S. residents age 18 and younger. All these questions can be answered by carefully reading this column. Write your answers neatly on a postcard or 4X6 card and mail to: *Rock & Gem* Kids Quiz, P.O. Box 6925, Ventura, CA 93006-9899. Valid entries received by Sep. 30, 2006 will be entered in a drawing from which five winners will be chosen. Valid entries must be the entrant's own work and must include the correct answers, the entrant's name, age and address, and the signature of a parent or guardian. Prizes are generously provided by the Arizona Mineral and Mining Museum Foundation.

1. The chemical name for fluorite is _____.
2. Fluorite crystals are usually _____ with _____ occurring at high temperatures.
3. Fluorite has a perfect _____ cleavage.
4. Fluorite dissolves in _____ fluoride acid to form _____.
5. Very low _____ allows lenses made of fluorite to deliver crisp images of astronomical objects.

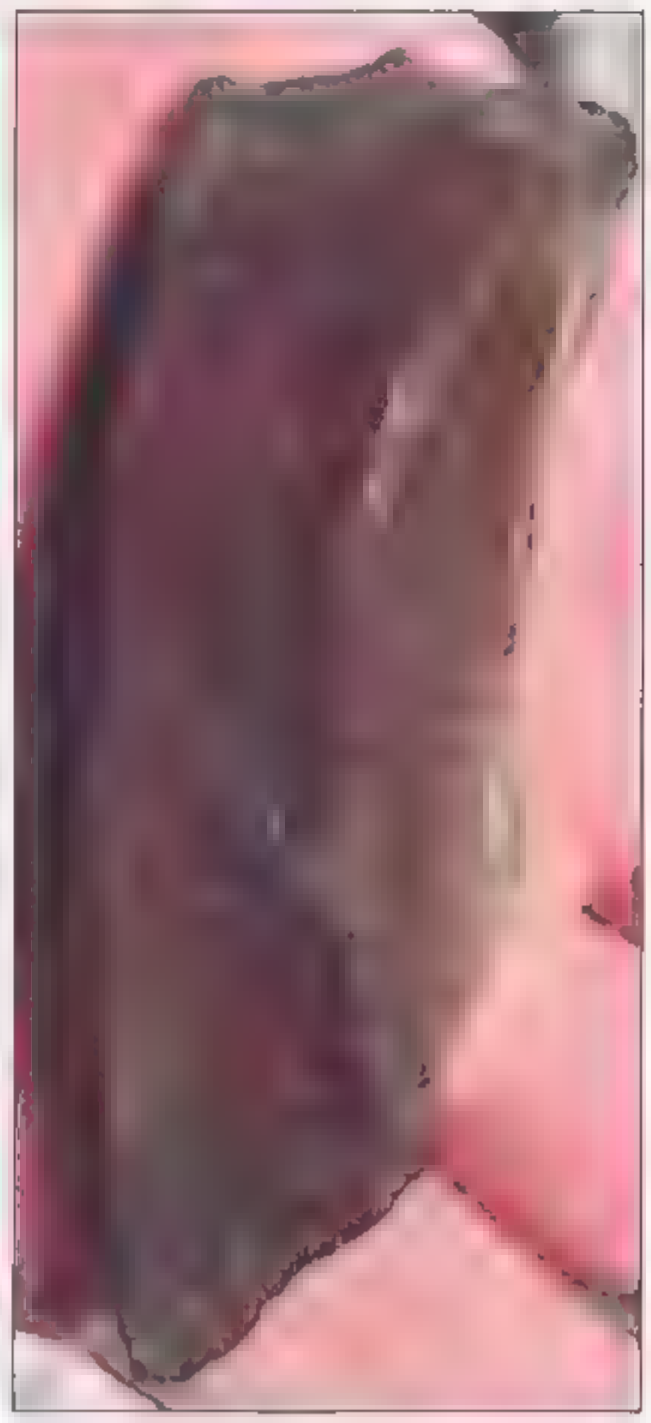
Phosphate Fossil Treasures

Richard Havens gleans black phosphate clams, shark teeth, vertebrae and bones from the sand on the banks of the Ashley River.

Easy Pickings on South Carolina's Coastal Plain

Story and Photos by Richard J. Jacquot

Living in the Western North Carolina mountains is heaven, especially for a rockhound like me. I can travel one to two hours in any direction from my home, just outside of Asheville, North Carolina, and spend the day collecting just about any gem or mineral my heart desires. Many collectors specialize in a certain gem or mineral or in specimens from a specific mine or location, while some collect only fossils. I like them all! While Western North Carolina ranks as one of the top locations in the country for rock hunting, the geologic makeup of our mountains prevents me from finding any fossils



This section of whale bone, collected at the Ashley Bridge site, has been replaced by phosphate and shows a nice red tint.

I sometimes lead collecting trips for rockhounds visiting from out of town. Many of my visitors come from the coast – Florida, Georgia, South Carolina, etc. – in search of gems from the mountains. Many of them tell me they wish they could live closer to the mountains to rock hunt and that all they collect at home are shark's teeth and various other fossils. I sometimes find myself thinking the opposite: How nice it would be to live where fossil bones and shark's teeth were as abundant as the gems here in the mountains.

My experience in fossil hunting was limited; I had made a few trips to a couple of islands off the Georgia coast and had found some nice specimens that, as an amateur collector, I was unable to identify. I searched a few of the local rock shops here in Asheville for a good fossil identification guide and finally found what I was looking for at the Silver Armadillo. The Armadillo (www.silverarmadillo.com) is Asheville's largest gem and mineral rock shop and has a quality selection of rockhound-related literature. I actually found two excellent fossil identification books, both put out by the North Carolina Fossil Club. "Neogene Fossils of North Carolina" and "Cretaceous and Paleogene Fossils of North Carolina" are both written by John Timmerman and Richard Chandler. The books are well written and illustrated, and I was able to identify all my previous finds from the islands I had visited.

continued on page 55

Two nice specimens of "button teeth" from an extinct Megalodon Shark were found in the Ashley River.

Phosphate Fossil Treasures *from page 51*

As my interest in fossils grew, I continued my treks to the Georgia coast sites I was familiar with. In 2003, I met a man named Jerry Fortenberry. Jerry had e-mailed me about joining the local rock club, the Mountain Area Gem & Mineral Association (MAGMA), and asked if he could join us on a trip we had planned to a local mine. Of course, I invited him along, as I encourage any new members to the club. I met with Jerry and his girlfriend, Tena, at the dig. Over time, Jerry and Tena became very involved members of the club, and we became good friends. I learned that Jerry, over the past 20-plus years, has spent much of his time in the Charleston, South Carolina, area diving for fossils and artifacts. Jerry, like me, enjoys collecting many things, rocks, minerals, and the fossils. Over the past few years, I have shared my rock hunting spots and experience with Jerry. In return, he is going to teach me about diving for fossils.

Jerry is a certified Dive Instructor and a licensed USCG Boat Captain, and operates the Indy Jones Trading Co., selling fossils, leading guided dive trips, and teaching scuba diving. After seeing some of the beautiful fossils he had found, I couldn't wait to get started, but I was still not certified as a diver and would not be able to get into a class for a few more weeks. That's when I found out there are many locations on the coast of South Carolina where diving is not required to hunt fossils. Of course, the best stuff is found by diving in the deep, murky waters of the rivers in and near Charleston. The Cooper and Ashley rivers are famous for the giant Megalodon shark teeth and numerous other fossils they contain, but there is plenty of nice material to be found without diving. I was thrilled that I only had to travel three to four hours from home to find the fossil treasures, a great improvement from my usual six- to eight-hour treks to the Georgia coast.

We planned our first field trip as a three-day weekend trip to various locations in the Charleston area. We made it a club event for MAGMA, and a few of us headed down on Friday. Jerry stopped at a couple of small creeks in the town of Summerville, near Charleston. We only had a few hours to collect the first day, but he wanted to show us that the good stuff could be found by simply searching the gravel bars in the creeks. In our limited time we found numerous types of fossils: horse teeth, shark teeth, ray teeth, vertebra, bones, and more.

We asked Jerry about the different fossils and what they are made of. He said the fossils are mostly mineralized teeth, bones, scutes, shells, wood, etc. In some cases, a shell, for example, the fossil has been completely replaced by calcium phosphate and is actually a casting of the original organism. Calcium phosphate is fossil mud or ooze that precipitated out of the ocean during geologically rapid climatic changes. The most sought after fossil is the tooth of the famous Carcharadon Megalodon, an ancient great white shark. These sharks grew to over 40 feet in length and left teeth for future fossil hunters that are over 6 inches long. I noticed that the majority of the phosphate fossils are black in color, but can also occur in shades of red, in tan, and with a bluish tint.

continued on page 58

A well-preserved fossilized horse tooth replaced by black phosphate was found in a small creek in Summerville, South Carolina.

That night, we found a hotel and spent the evening examining our finds. I had collected more that day than on any of my previous trips, and had found many new species to add to my collection.

Saturday morning, we met with the rest of our club members and caravanned to our collecting site for the day. The site, located on the Ashley River, is a popular location for local fishermen. The locals watched as our members, buckets in hand, began to scour the sand beach for fossils. Some of the fishermen, curious as to what we were doing, soon joined us in our search. After only a few minutes, Tena had recovered a nice sized whale vertebra. Every few moments, someone would shout when they found a nice specimen. Black phosphate clams up to 2 inches in diameter were abundant, along with a variety of shark teeth, vertebrae, and bones. By the end of the day, our buckets were full and we headed back to our hotel for another evening of cleaning and admiring our finds.

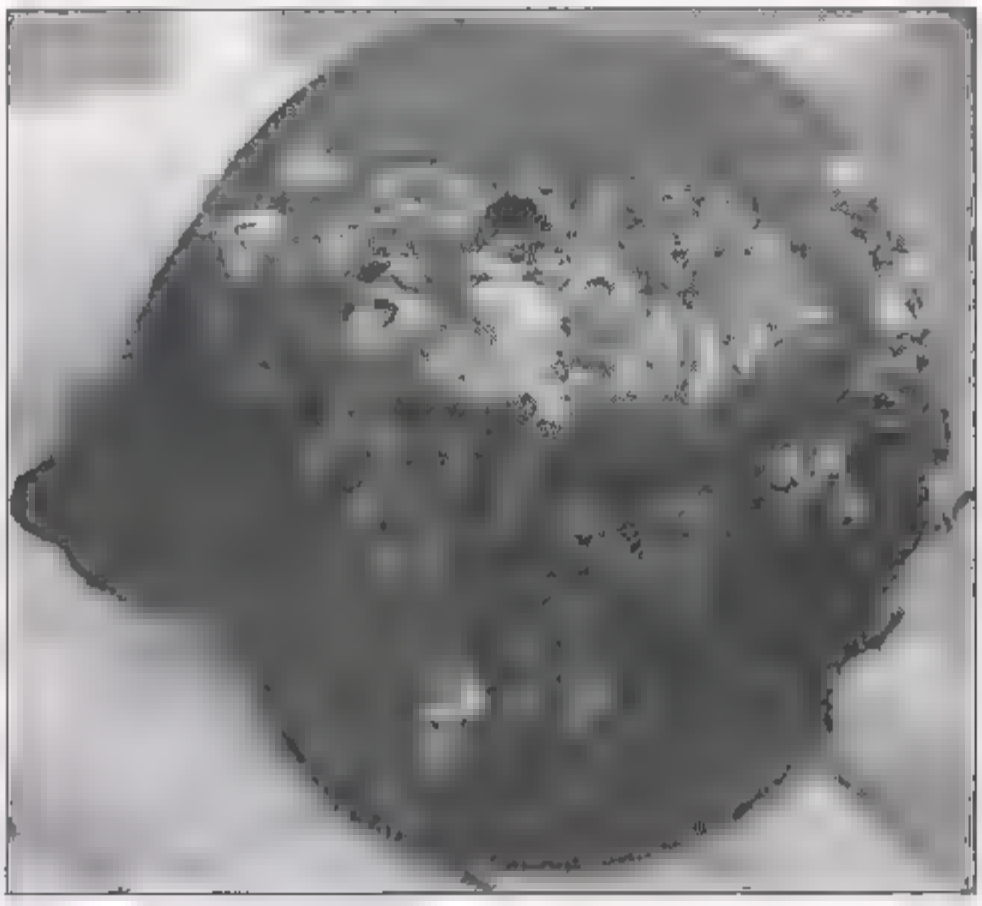
Sunday came, along with several thunderstorms and a lot of rain. While most people would have packed it in for the weekend, we headed to a nearby drainage ditch in town to collect. The ditch was about 4 feet deep in water; the depth varies with the tide. Stopping by a local Wal-Mart store, we bought some foam tubing and rigged up some floating sifting screens to use in the water. By probing the bottom of the ditch with our shovels, we would locate a gravel bar, shovel the material into the floating sifter, and then examine the contents and pluck out the fossils. The ditches that are located throughout the area are natural creeks that have been expanded into drainage ditches to control tide waters. They cut through the fossil-bearing layers, and the constant changes in the tide levels cause the fossils to wash into the bottom of the ditch and collect in gravel bars. The ditches and creeks in the area drain into the Ashley River.

Being a rockhound, I like to learn about the history and geology of the different sites I collect at. I had done some research on the South Carolina Coastal Plain and learned that

South Carolina's phosphate fossils include shark teeth, fish vertebrae, clam fossils, and ray teeth.

the Ashley Formation of the Cooper Group and the Chandler Bridge Formation represent the only Upper Oligocene units recognized in the outer Coastal Plain of South Carolina. Vertebrate remains are common in the Chandler Bridge Formation, which contains a mix of phosphatic, muddy, calcareous, very fine-grained sand that had been termed the "Ashley Marl" (*Geology of the Carolinas* J. Wright Horton and Victor A. Zullo ed., Univ. of Tennessee Press, 1991).

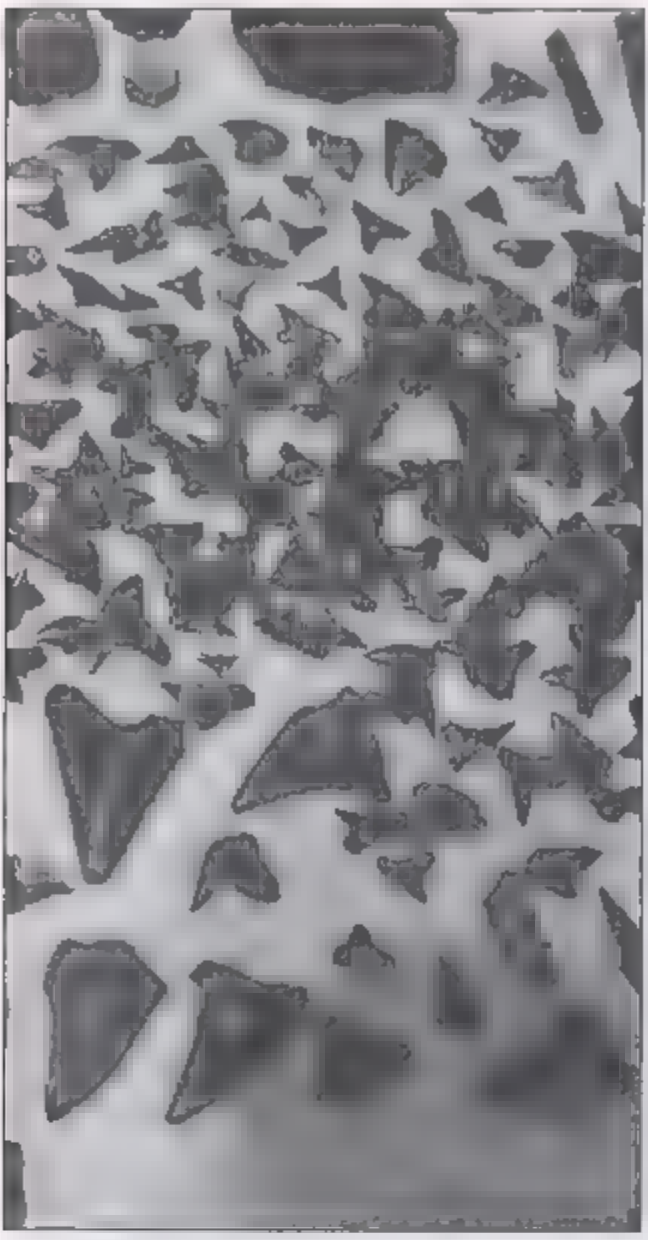
I asked Jerry for more information about the area, and he told me what he had learned over the years. South Carolina is divided into five geologic zones or regions. These zones cross the state in a northeast-to-southwest direction, running parallel to each other. In the Coastal Zones, fossils are found below the "fall line," the shoreline of ancient beaches as the ocean inundated and receded across the state during our geologic pre-history. As a result, both land and marine fossils are commonly found in the Coastal Zones. In the Summerville area, the fossil-bearing sediments are called Cooper, Ashley, and Chandler Bridge. The Chandler Bridge Formation contains the larger fossils, and this layer is often exposed during new construction excavations or by the erosion of creeks and rivers. Most of its fossils are from the Cretaceous Period or more recent. It's interesting to note that fossils from the Cambrian Period, such as trilobites, are also found in South Carolina. These trilobites are evidence of plate tectonics and South Carolina's connection to the African continent.



A well-preserved specimen of a whale vertebra, covered in barnacles, was found at the Ashley Bridge site.

At the end of the day on Sunday, it was time to pack up our equipment, homemade floating screens, and containers full of great fossil specimens and head back to the mountains. What a weekend we had, finding beautiful fossils for our collections. All the club members went home happy, and we had learned a great deal about fossil collecting and the geologic past of the South Carolina Coastal Plain from Jerry. He taught us that you don't have to be a certified diver or own a boat to find some good stuff.

I love living in the mountains of Western North Carolina and wouldn't trade it for anything, but I love fossil collecting as much as mineral and gem collecting. Thanks to Jerry Fortenberry, I can now afford to do both whenever I want. I plan to be certified as a diver as soon as possible in order to take my fossil-hunting adventures to the next level. Collecting in the creeks and streams is fine and you will find many great things, but Jerry has told me about a whole different world under the murky, deep waters of the rivers that run through South Carolina, finds of huge Mastodon teeth, artifacts, and giant



Various types of shark teeth were found by screening the gravel in a local creek in Charleston, South Carolina.

teeth from the ocean's greatest predator ever, Megalodon. This is a world that only a certain type of people will ever get to see, ones who put their fears aside and let the spirit of adventure and exploration take over. If you think you are one of those people, visit www.WNCRocks.com and click on the quick link to the Indy Jones Trading Co. page to contact Jerry Fortenberry about dive classes and guided dive trips to the Cooper and Ashley rivers and other fossil-rich areas in South Carolina. It may be the adventure you've been waiting for!

To try your hand at collecting at one of the more productive sites we visited, follow these directions: Driving Interstate 26 West toward Charleston, take Exit 216 (state Route 7) toward Folly Beach. When you've nearly crossed the Ashley River bridge, turn right and drive down underneath the bridge. Park anywhere and collect on the beach. Bring a sifting screen and shovel. We found phosphate clams up to 2 inches in diameter, whale vertebrae, shark teeth, fossil bones, and much more.

While in the Charleston/Summerville, South Carolina, areas, take time to check drainage ditches, creeks, and riverbanks. Almost all of these areas will contain fossils of some type. Be sure to ask permission to access the site when appropriate.

Liquidating a Rock Hobby Estate

LOT #624

Part II:

Holding a Sale without Getting Burned

Story and Photos
by Larry C. Field

Editor's Note: ***The author of this article is not a lawyer. No part of this article should be taken as valid legal advice. The information contained herein should be used only under the advice of a qualified legal professional.***

Keeping your hobby items organized will increase your enjoyment of the hobby. Now, what do you want done with your hobby possessions when you die? There is a variety of answers to this question, one of which might be, "Why would I care?" Other more serious answers may include, "Have my heirs divide and keep them," "Give them to a friend, school, museum, rock club, etc.," and "Sell them to generate income for my heirs."

Contemplate these answers for a minute. None is as simple as it seems. Each of the answers involves many challenges. For example, what is involved in leaving the items to your heirs? Do the heirs even want them? Do they want your whole collection, or just a small, nice display of finished pieces? Who would be included as an heir? If you include only one cousin, because of her interest in rocks, does that open the door for all other cousins to file legal claims? Who gets what? Do the heirs divide by choice, value, weight, etc.? If by value, how is the value determined? Who gets first choice? Is your collection valuable enough that this decision will result in legal action? Believe me, many heirs switch from Dr. Jekyll to Mr. Hyde when money or value is involved. After all the quarreling is done, how many years will it take for your heirs to return to speaking terms with one another?

Rocks should be displayed in flats so they can be easily viewed. The low-value rhyolite can be sold in lots, the high-value dryheads should be sold individually or in matched pairs.

This is just the beginning of the list of questions I have been involved with each of the above types of liquidation and none are easy. I also have current friends who have asked me to take care of their hobby collections for their heirs when the time comes. I have clarified as many issues as possible ahead of time, preferably in writing.

Probably the best way to handle these issues is to gamble with fate, choose a point in time when you aggressively reduce inventory, and manage the reduction yourself. This seldom happens, but may ultimately be the best decision. It is also a very risky decision. How long do you dare wait? How much do you keep? How can you continue to enjoy the hobby if you liquidate tools too early? When the owner loses interest in the hobby, this is definitely the choice to make, in a timely manner.

Consider your possessions, your choice of hobby, and your age. If you have two tons of rocks and make about one sphere per month, are you going to live to be 12,000 years old? I am continually chiseling away at my accumulation. One good way is to trade down in size. I once traded a 300-pound geode for a 1 carat faceted sapphire, a good estate reduction move.

SELLING AN ESTATE

After you decide what you wish to have done with your collection when you pass, you must inform your primary heir. If you want to sell the estate, you should even discuss the type of sale. There are many options, and each is correct in certain circumstances. You should also advise your primary heir of the approximate value of the merchandise as a whole.

Outdoor rock storage areas should be rust-free environments. These Montana agates are stored in wire milk crates with identification tags.

Unless the heir has an advisor who can be unquestionably trusted, the heir must have an idea of the approximate value to make the logical decisions concerning the type of sale.

In one case, a life-long collector had done extensive serious collecting and purchasing. He also did a good deal of cutting and polishing to make finished specimens and jewelry, which he sold while living. As a result of his 40 years in the hobby, he had cut, polished and sold most of the nicest pieces and accumulated huge piles of the poorest materials, which were piled around his yard. When I went to help his widow, who was not a rock hobbyist, she remembered that select, polished rocks had sold for $300 each and therefore assumed that I should be able to get that value out of each piece of unfinished junk lying around the yard. Pending heirs of the hobbyist need to be told by the family hobbyist prior to failing health that this is not a realistic expectation. One would not lay $100 bills around the yard, so why would he put $300 rocks there? This individual still has piles of low-grade material cluttering her yard years after the passing of her husband.

Potential sale techniques include auctions, outright sale of the entire collection, piece-by-piece sale, and Internet sale. Each has a place, depending on the collection. Some collectors, like my friend, have already sold the valuable pieces and primarily low-value material remains. This material might be sold in a lump to generate some revenue and to clear the mess. It might even be given as a donation, approved by the IRS as being tax deductible, with a maximum acceptable value appraisal, which could potentially result in a tax savings approaching the sales value of the accumulation.

Collectors like me spend a lifetime collecting and buying to create the best possible private collection. This might suggest an auction. If a collector puts together a terrific, but small, perhaps one cabinet, collection, an Internet sale, in which the seller sets the price, might be viable. Other circumstances may dictate other types of sales.

Probably the two poorest choices to make following the death of a loved one are to delay having the sale and to clean house, piling the rocks outdoors. Since the primary heir will be grieving, rushing the sale, even though important, will be difficult. That is why the rock hobbyist, while living, should consult a trustworthy friend about helping when the time comes. Frequently, when the sale is delayed, the rocks will be moved to storage of some sort and in the process items are damaged, labels are lost, and the value will go downhill. The worst possible choice is to pile the rocks outdoors, exposing them to the elements and to potential theft.

In this day and age, nothing of value is safe in a yard for too long. In one case in which I assisted, the widow commented that a quite large and valuable collection had been piled out in the orchard about 20 years ago. When we walked to the orchard to view the pile, she commented, "I cannot believe how erosion has spread the rocks." What had started as a cone-shaped pile had become a large circle not much thicker than one rock layer. It wasn't erosion at work, but 20 years of theft. What was presumably a valuable collection had been reduced considerably in value by removal of the most valuable pieces.

ADVERTISING

Advertising your sale is paramount. Everything of significant value must be advertised, and the notice should reach a maximum number of rock hobbyists. This is a big order, but it is crucial, and will reflect in revenue. Items not advertised will sell too cheaply. A large estate should be advertised in national lapidary magazines such as *Rock & Gem* referencing a Web site, e-mail address, or mailing address for obtaining details such as a list of sale items, the weight of items to be sold, the payment type required, etc. The ads in national magazines should be placed well in advance, since many have four- to six-month lead times. The magazine ads should be published well in advance of the sale to allow potential bidders time to acquire sale information, schedule travel time, etc. The sale should also be advertised by sending handbills to all regional rock clubs and perhaps even all state rock club members. Ask all rock clubs to reprint the ad in their newsletters for their members to see. Single-sheet photocopies are inexpensive and should be utilized liberally to contact potential rock hobbyist buyers. If a large weight of rocks is to be sold, say so in the ads and suggest that bidders come in pickup trucks.

Any type of sale must be properly conducted to generate proper sales and income. Large sales must be extensively advertised. Each item of value must be advertised to draw buyers for that line of merchandise. Merchandise must be properly identified, clean, and visible. Sales rules must be strict, posted for all to see, and enforced. It must be obvious to those viewing and buying the merchandise that they are being watched. Small, high-value items such as gold, gemstones, jewelry, coins, pistols, first-edition collector's books, etc. must be encased or placed out of reach for protection during the sale.

The items to be sold must be clean and orderly. I once attended a farm auction that included an oval iron tank that had been torched in half, filled with rock, and left outdoors for years. The tank contained about a ton of rust-coated rock, each piece looked as if it had been spray-painted rust brown. The tank had obviously been full of water for years, the top surface of the rocks was covered with nearly an inch of rust scale, dirt and debris accumulation. It was such a mess that most of those present didn't bother to look at the rocks. I was able to identify the rust-coated material by the size and shape as being dryhead agate nodules. I bought the entire tankful for $65 at a time when top-quality dryhead was retailing for $50 per pound.

continued on next page

These dryhead agates should have been removed from the tank, hosed off, and placed into flats. One rock in each flat should have been bisected with a saw or chipped with a hammer to reveal the dryhead pattern below the rust coat. Even more important, the ad should have included the fact that a ton of dryhead agate would be sold. Had this been done, these rocks should have easily sold for a much higher amount.

If you choose to auction your possessions, their value is determined by the bidders; valuable items may sell for nearly nothing if none of the bidders present are interested. Such a possibility must be strongly considered if one chooses to host an auction. The auction company you employ should be familiar with state laws. If legal, you may choose to place minimum bids on the items. The buyers won't like this, and it may result in some items not selling. Any item worth a good deal of money must be specifically mentioned in the advertising so that those interested in that item may choose to attend the auction. Another major consideration is the fact that the auction company may collect half or more of the income from the sale for its fee.

When assembling the merchandise for sale, one must consider how much demand there will be for each of the items. Tool accessories are a perfect example. Many buyers present will own the basic rock hobby equipment, such as saws and tumblers. New saw blades, grinding wheels, and abrasive grit will generally generate enough interest to be sold independently. However, in the case of accessories for less common lapidary tools, such as sphere machines, facet machines, and drills, you may generate more income by selling the accessories with the tool. The individual buying the tool will want the accessories. A rock drill bit, for example, would be of little value without a drill, so it wouldn't generate much income if sold without the drill.

This 60-foot length of yard is divided into thirds. Identification tags hang on the base of the chain-link fence adjacent to each rock type.

Landscape islands work well for rock storage. Identification tags may be attached to the wooden edge.

I attended a well-run auction in Nebraska a few years ago. Bidders were present from nearly all parts of the country. During previewing, I identified seven pieces that I would like for my collection and several other flats of material that I would bid on for trading stock if they went cheaply. The auction had been well advertised and the material was all clean and properly presented. Every item that I was interested in sold for near retail value or higher. By the time the last of the seven items I wanted came up for bidding, I had yet to win a single one. At this point, I decided that I wasn't going to travel home to Montana with nothing, so I decided I would purchase this last item. I purchased the 1-pound Mexican dendritic agate for $400. This auction and the farm auction certainly reflect the difference in rock prices between well-run and poorly run sales!

DONATIONS

Don't forget that donations to museums and schools may be tax deductible. In some cases, the tax deduction may aid the estate enough so that an outright rock sale can be avoided, thereby eliminating all of the work and risks involved in holding a sale. Schools and museums are frequently interested in nice donations. This is an option to consider, but if you are making the donation for tax reasons, confirm with an accountant or the IRS that it will be legally tax deductible and find out exactly how the value is to be determined. This will require an IRS-acceptable appraisal.

I hope that you have found some valuable information in this article. The grieving heirs will have fewer concerns if the hobbyist has properly prepared his collection and advised his heirs while enjoying his hobby. Prior to making any decisions on a sale of any kind, you should definitely consult your professional financial advisor. You may even show the advisor this article, as she probably will not be a rock hobbyist and may be more able to advise based on the contents of this article. Remember, if you choose a sale of any type, your loved one's prized possessions will be passed on to others who will display them with pride. Also remember that any type of sale is risky, dependent on the whims of the fickle buyer!

Rockhound's Honeymoon

A bag of gem gravel from the Desoto Caverns made a good gift for our grandchildren Kody, Tyler and Lindsey.

Part II: Gem Panning and Petrified Forests

Story and Photos by Kenneth H. Ronn

When we left Arkansas' Ouachita Mountains, Betty Carol and I traveled east toward the Petrified Forest in Flora, Mississippi. The "Magnolia State" covers 46,907 square miles, and its highest point is Woodall Mountain, 806 feet above sea level.

Betty Carol mentioned that, although she had traveled through the state, she never had time to actually enjoy it, especially not on a field trip with a rockhound husband. My travels had taken me to Mississippi on occasion before we were married, and I was looking forward to seeing it again.

Early on, Mississippi made an indelible impression upon me. Its scenery is very photogenic. There's beauty in the vast nut groves, their ancient trees heavy with fruit. When the magnolias bloom, no number of adjectives can define their beauty. As I write this, I can visualize the peanut and cotton fields, a brilliant green against the backdrop of red soil. The gnarled cypress trees and stands of evergreens make a wonderful contrast with the blue sky and the equally blue water of the bayous.

I always enjoy the majestic palms growing along the boulevards, their fronds swaying in a gentle breeze, but most of all, I have retained a vivid mental picture of the beautiful, old mansions set on a gentle rise of green lawn with a border of Spanish moss-laden trees. They're magical.

The gem gravel from Sequoyah Caverns contains a variety of up to 40 different kinds of gemstones

Although the Mississippi Petrified Forest is not a collecting site, there are areas in both Wayne and Jones counties where petrified wood can be collected. It's been a while since I collected wood in gravel pits near Laurel and Waynesboro, so I cannot give detailed information, but there's potential in these areas and it might be worth your while to investigate further. Contact the Chamber of Commerce in these areas and the Highway Department. Local clubs may lead you in the right direction, as well. When you get the necessary information and acquire the permission to collect, you're in business.

Visiting the Mississippi Petrified Forest is an educational experience for those of us who are interested in the geological history of our earth. It's not only a Registered National Natural Landmark, it also is the only known petrified forest in

the Eastern United States. It lies a bit to the southwest of the town of Flora, which is but a few miles northwest of Jackson. Jackson is the state capital and is the largest city in the state with a population of 179,298.

Betty Carol and I arrived at the petrified forest in the mid afternoon of a bright, sunny day. The better half simply loves to shop, and when we entered the large, well laid out Visitor Center and she saw the vast array of gemstones, memorabilia and rocks everywhere, she simply had to take time out and admire things. This large rock shop was a different shopping experience for her. She managed to purchase a cap for me and a hat for herself, plus an assortment of pretty rocks, before we went on the self-guided tour.

The tour at the Mississippi Petrified Forest is approximately five city blocks long. The trail takes us through a forest of living trees interminged with numerous petrified logs that came to rest here in the past. Signs at each stop point out special features of a log or group of logs. A printed trail guide is included with the fee. The trail begins at the shop and ends at the Earth Science Museum. Here an array of petrified wood, minerals, and fossils found in the area is on display.

The majority of exposed logs in the forest are huge. The larger ones are anywhere from 3 to 7 feet in diameter. Several of the logs are only segments of the once living trees. Over time, pressure and stress due to earth movements have caused many of the petrified logs to fracture. Some are only partially exposed in the embankments along the trail, so there's actually no way to determine just how long they are. Others are found resting right on the surface. They are somewhat water worn, but readily identifiable as once-living trees.

The earliest known discovery of these trees was recorded in 1854. At that time, shortly before the Civil War, news traveled slowly, so nothing much was done to either preserve or collect the logs that were exposed for a good number of decades.

The giant remnants of evergreens and some deciduous trees came to rest here after drifting downstream from an unknown place far to the north. The evergreens resemble sequoias, and studies suggest that the deciduous logs may be similar to our modern-day maples. The trees are said to have drifted into this area on a great, prehistoric river flood during the Oligocene Epoch in the Tertiary Period, some 38 million to 36 million years ago. Their approximate age has been determined by paleobotanists, who studied the original Forest Hill formation soil entombing the trees.

It has never been definitely ascertained or understood just how long it takes to replace wood fiber matter with minerals. Scientists have come to the conclusion that the only way petrifaction can take place is with the complete absence of oxygen. Thus, if anything is to petrify, it must be buried quickly and sealed away from the elements for millions of years. Gradually – no one knows for certain just how slow this process was – as the wood decayed, it was replaced by aqueous hydrothermal minerals in solution. In many cases, each cell, each and every feature of the living tree, has been faithfully duplicated with a variety of minerals, primarily quartz. Quite often, even the color of the wood has been duplicated, or shows a reasonable facsimile of the once-living tree.

As those millions of years passed, erosion began to expose the logs. No doubt, a prior catastrophic event had felled the trees. They eventually floated downstream to their final resting place here in Mississippi, where they turned to stone over the ages. Trees that have grown to those proportions are bound to be several hundred years old, possibly over a thousand years, depending upon the growing conditions at the time. It's mind boggling, isn't it?

To my knowledge, no physical evidence of the river that carried these trees downstream exists today. Over the eons, many feet of overburden covered them. During the drilling of a well recently, the drillers punctured a log 75 feet below the surface. One wonders just how many logs are down there and how deep the deepest ones rest.

As time slowly passed, the logs were gradually exposed much as we see them today. Like those in the Arizona Petrified Forest, these logs are bare of limbs. Most, if not all, the limbs were torn away during the turbulent trip downstream in a wild, raging river.

Betty Carol and I enjoyed the walk, studied the trees, took photos, and spent the better part of the afternoon at the forest. Then it was time to go. Our next stop was Desoto Caverns Park, situated in Childersburg, Alabama, some 200 miles as the crow flies to the northeast. This city is southeast of Birmingham.

We drove east into the "Yellowhammer State" on Interstate 59, then took state and county roads to Childersburg. This is rather mountainous country by eastern standards and very picturesque. The highest point in the state is Cheaha Mountain, at 2,407 feet.

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Visitors to the Sequoyah Caverns witness the process of the production of limestone, which is going on continually.

We were in no hurry, traveling at a restful pace and enjoying the scenery along the way. A good deal of the time, we were deliberately away from the hustle and bustle of heavy traffic on well-maintained secondary highways. We spent the night in a picturesque and quiet park situated in the rolling hills of Alabama a short drive away from the caverns.

The Desoto Caverns feature many attractions for children as well as adults, including an underground tour of the caverns. The one that interested us the most was the gem panning area. We thought of our grandchildren and how they'd have enjoyed this outing. Youngsters, as well as grownups, can get actual experience in panning for gemstones in the well-laid-out washing facility. The park also sells bags of dirt containing fossils and artifacts that can be taken home and screened. We purchased some just for that purpose. Our grandsons Jared, 10, Kody, 7, and Tyler, 5, are already avid rockhounds. Our granddaughter Lindsey, 2, will soon be joining them, if my guess is correct.

When we approached the panning area in this large park, we watched a family washing bags of gem dirt. The children were having a ball. Naturally, the dirt is concentrated to enhance the process and enjoyment. It gives the patrons a better chance of finding a variety of minerals in their bags.

We bought a couple bags of dirt and each of us received a gold pan. This washing procedure is by no means new to me, as I've spent untold hours bent over a gold pan in the west. It was, however, a completely new experience for Betty Carol.

I watched as she washed her pan of dirt, giving her a tip now and then, but overall she did a good job and succeeded in recovering a variety of minerals. We found specimens of amazonite, quartz, rose quartz, blue calcite, iron pyrite, garnet, citrine, fluorite, and aventurine. The largest specimens we recovered are ¾ inch in diameter. The smallest are well-formed, golden pyrite nuggets approximately ¼ inch in size.

While Betty Carol panned some of her dirt, I went to the camper and got out my gem screen. It's 12 inches in diameter and one of the handiest prospecting tools that I have in my collection. It was designed specifically as a testing implement. It has a very fine mesh that retains anything over 1/16 inch. My intent was to give the better half a chance to experience the use of a screen while recovering gemstones. All you need is a source of water and a little elbow grease. After I showed her how I do it, she quickly caught on and washed a portion of the dirt in the screen. The dirt quickly washed away with a swirling motion, leaving a pretty array of different colored minerals in the bottom of the screen. We had a most enjoyable time at the Desoto Caverns and Betty Carol was rapidly improving her skills as a rockhound.

It was time to move on. Our next stop was Sequoyah Caverns & Ellis Homestead, situated in the rolling hills near Valley Head, Alabama. It's just about 200 miles from Chuldersburg to Valley Head via I-59 and state and county highways. Georgia is but a short drive to the east of Valley Head on state Route 117 and northeast on I-59. The scenery is spectacular along the route. Wildflowers and fruit tree were blooming everywhere we looked.

We arrived at Sequoyah Caverns shortly before sunset and checked in at the campground office/store. Our site was a short walk away in a beautiful setting on a hillside, with a lush green meadow as a backdrop. There are 85 campsites with electricity and water, plus 15 with full hookups, in the complex. Reservations are suggested, but they're really not required. The caverns are open seven days a week from March to November and weekends from December through February. The Ellis family history dates back 165 years, when James Ellis settled in Valley Head after moving his family from Tennessee in 1841. His descendants live here and operate the business today.

After a substantial evening meal, Betty Carol and I played cards. Naturally, she beat me at almost every game. It was peaceful in the campground and sleep came easily. We had a big day coming up, and I drifted off to sleep thinking of all the places we had visited during this trip. So far, it had been phenomenal.

Shortly after breakfast, we put the camper in order and drove on down to the gift shop and gem mine a short distance away. We made arrangements to wash some gemstone dirt and take the cavern tour. I like the efficient washing facilities. Fresh water flows into the trough from the creek above. The trough itself has been engineered and built to the width of the washing screens, which rest on the lips of the trough. The screens are made deep enough so that the bottoms always rest in moving, clear water. All one has to do is pour in the dirt, move the screen back and forth in the water, and presto! the vast array of gemstones appears in a matter of minutes.

You can buy bags of gem dirt or fossil dirt. It's possible to discover 40 types of minerals in the gem bags and 32 different fossils in the fossil bags. The specimens come from around the world, and they are quite a variety. Some of the gems that might be recovered are rubies, emeralds, agate, aventurine, quartz crystal points, bloodstone, and garnets. Some of the 32 fossils that can be recovered are oysters, coral, snails, fish vertebrae, shark teeth, and amber.

We had just finished washing our gem dirt when the next cavern tour was announced. I put the zip-lock bags of gemstones in the camper and grabbed a couple of light jackets, and we joined the group. It's cool enough in the caverns to wear a sweater or jacket. Upon later inspection of our gemstones, we learned that we have a wonderful collection of stones. We found a very nice specimen of amazonite, 2 inches in diameter, water-

The Mississippi Petrified Forest trail winds through a forest of living trees intermingled with numerous petrified logs.

clear quartz crystal points, garnets, rose quartz, honey calcite, emerald calcite, two arrowheads (one is obsidian), and a rainbow of colorful stones that fit a paper plate.

The Sequoyah Caverns are vast. The processes of nature are quite amazing. As our eyes became accustomed to the dimness of the caverns, we saw gigantic rooms, long passageways, and a labyrinth of small tunnels branching off the main pathway. The entire tour route is well lighted, and our guide gave a most interesting and educational talk.

Stalactites and stalagmites have formed in the strangest and most grotesque configurations, and they continue to grow, drip by drip, from limestone minerals in solution. Although it may not occur to us, we are witnessing the process of the production of limestone, which is going on continually before our eyes, in the caverns.

Many pools of water along the way are so still they are perfect mirrors, reflecting the projections from the ceiling. The walkways are rather easily negotiated, with only a few steps here and there. One interesting feature of the caverns that drew our attention is the fact that a signature on the cave wall is believed to be that of General Sam Houston.

The gem gravel from Sequoyah Caverns contains a variety of up to 40 different kinds of gemstones.

After the tour, we were on our way south to Florida. Our travels were to include an unusual, but most interesting and exciting, side trip to the town of Wabasso, Florida, where I would take part in a metal detecting contest.

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Rock Science

by Steve Voynick

Bismuth: More Than Pretty Crystals

Clusters of "hopper" crystals that gleam with bright, iridescent blues, greens and yellows are big sellers in rock shops and at gem and mineral shows. Their shapes are no less intriguing than their colors. They typically form cubes with outward-extending edges and repetitive, parallel inner "stair steps" moving downward into concave centers. These familiar hoppers are laboratory-grown crystals of bismuth – the only pure, elemental bismuth most of us ever see.

Bismuth is a silver white metal with a hint of pink and, sometimes, a faint multicolored tarnish. It is quite soft at Mohs 2.0-2.5 and has a low melting point of just 520 degrees F (271 degrees C exactly), lower even than that of lead.

In crustal abundance bismuth ranks 73rd among the elements and is about as common as silver. Bismuth occasionally occurs as a native metal, usually in massive form; well-developed crystals are rare. Its most common minerals are bismuthinite (bismuth trisulfide, Bi_2S_3) and bismite (bismuth oxide Bi_2O_3). Both are mainly found in trace amounts in lead, zinc and silver ores.

Bismuth is sometimes described – erroneously – as the "heaviest" natural element. Because of its large atom, bismuth has a high atomic weight of 208.9, higher than that of gold and platinum, but not as high as such natural radioactive elements as uranium and thorium.

But atomic weight and density (think of density as "heft in the hand") are only modestly related. Bismuth's density, as expressed in specific gravity, is only 9.8, a bit less than that of silver. The reason for this is loose atomic packing. Because bismuth atoms are distanced from each other, their metallic bonding is relatively weak, which explains both the metal's softness and its low melting temperature.

Long confused with lead, zinc, antimony, and tin, bismuth was finally identified as an element in 1753. Its name derives from the old German *wismut* or "white mass."

Today, bismuth and its compounds have many uses. Metallic bismuth expands slightly upon solidifying, a property shared by only two other common materials, water and antimony. This makes bismuth a valuable addition to casting and soldering alloys, as it enables them to fill every detail of a mold and to completely seal soldered pipe joints.

No other material has bismuth's diamagnetic character, or ability to repel magnetism. Because its electrical resistance actually increases in magnetic fields, thin slivers of bismuth align at right angles to magnetic fields, a property that makes it useful in instruments that measure magnetic intensity.

Because bismuth is nontoxic, it is increasingly used as an alternative to lead in the manufacture of shotgun pellets, fishing sinkers, ceramic glazes, and plumbing solders. Bismuth compounds have long served as soothing remedies for upset stomachs. For example, the "Bis-" in Pepto-Bismol reminds us of its active ingredient bismuth subsalicylate.

While pure bismuth has a low melting point, those of certain bismuth alloys are even lower, some even below the boiling point of water. These make ideal alloys for the heat-liable "plugs" in automatic, sprinkler-type fire-protection systems, which constitute the biggest single use of the metal.

Bismuth is recovered as a byproduct from the smelting of precious- and base-metal ores, primarily those of lead. About 4,000 metric tons of bismuth are recovered worldwide each year, mostly in China and Peru. Bismuth sells for $3.20 per pound. That's certainly affordable enough to keep laboratories turning out those popular "hopper" crystals.

Bismuth "hoppers" are made by melting metallic bismuth, then letting it cool slowly so that it crystalizes from the outside in. When about half the molten bismuth has solidified, the crystals are removed. There are many tricks to this trade, but, generally speaking, the purer the bismuth, the better the crystals.

Also, because bismuth crystalizes in the rhombohedral system, those little hopper cubes really have a pseudocubic habit and are not true cubic crystals. Likewise, their colors are not those of metallic bismuth, but of a thin film of bismuth oxide that coats the new crystals and diffracts light into all those wonderful, iridescent colors.

Volcanic Iceland

It's a Geological Hot Spot

Story by Kiera Tara O'Brien

Four hours out of Norway's Gardermoen airport, three adventurous companions landed in Reykjavik, Iceland, determined to tackle the isolated country and its famed landscape. Armed with a rented Suzuki Grand Vitara, one mid-sized tent, a whole lot of chocolate cookies, and Johnny Cash's Greatest Hits, our transnational "expedition" (two Norwegians and one Californian) would discover a terrain unlike any of our pre-arrival expectations. This is a speckled land shaped by the collision of "fire and ice" and best described by our master fly-fisher, Kim-Roger: "This place just doesn't make sense!"

The North Atlantic region, well known for glaciers, Viking raiders, and the Titanic disaster, is home to some of the oldest and youngest sediments and rock formations on Earth. Stretching 18,000 kilometers across the floor of the Atlantic Ocean and straight through the center of Iceland, the Mid-Atlantic Ridge is the point of separation of two of the Earth's large tectonic plates. These plates, forced apart by insistent molten rock (magma) from the Earth's core, are constantly moving farther apart, increasing the distance between North America and Eurasia by a few centimeters every year.

The movement of tectonic plates along the Mid-Atlantic Ridge also produces volcanic and seismic "hot spots." Iceland is the largest island formed by continuous volcanic activity at one of these hot spots. The Mid-Atlantic Ridge splits the island down the middle, creating a tumultuous rift zone characterized by an extensive system of fissures, geothermal surface activity, and volcanoes. Throughout Iceland, there are several active and dormant volcanoes, as well as more than 250 geothermal spots and 770 hot springs.

At the interior of the island, some of the world's newest sediment can be found, while the age of the western and eastern coastal formations are estimated at around 16 million to 17 million years old. Nearby Greenland is even more ancient than Iceland. It is composed of a rocky terrain largely made up of gneiss, marble and granite formed early in the Earth's life.

While Iceland possesses far more vegetation than Greenland, constant volcanic and glacial action underneath and on the island has produced an unusual jigsaw puzzle of desert plateaus, lava fields, sand deltas, geysers, hot springs, mud pots, fumaroles, waterfalls, rock cliffs,

KIERA TARA O'BRIEN PHOTO

tundra, and ice caps, a landscape that often seems more suited to the Martian planet than our own.

The first two hours of our grand expedition were spent lost on the streets of Reykjavík, Iceland's growing capital and one of only three settlements on the island that can be categorized as a city. Many Icelandic towns marked on the map, as we discovered, were simply three or four farmhouses grouped together, sometimes with a small church.

Eventually, our Norwegian navigators, Kim-Roger Asphaug and Sindre Øen, struck the right route out of the capital and we headed off through the mossy lava fields toward the southern part of the country. On this southern route, we got our first taste of the Icelandic wilderness and we soon realized we had stumbled across a geological bonanza. Palagonite, dolorite, rhyolite, obsidian, and basalt are the main types of rock found in the south of Iceland. These are all produced by and transported around the area through a complex system of above-ground and underground lava flows from five of Iceland's imposing volcanoes: Eldigjá, Lakagigar, Mount Eyjafjöll, Mount Katla, and Mount Hekla.

Basalt is the most commonly known type of solidified lava. It is an extrusive igneous formation, similar to rhyolite. It is typically a fine-grained rock, black to dark gray in color, and consists of anorthite feldspar or pyroxene.

Made up of devitrified volcanic glass, in which the silica is partially removed by the weathering process, palagonite is similar in appearance to obsidian. It consists of large and small fragments of basaltic glass.

Rhyolite is formed when light, acidic lava solidifies into unique, light-colored, variegated shapes that are high in silica. It most often appears as sanidine feldspar with biotite, magnetite and albite. In Iceland, this rock formed in large fields stretching many kilometers.

Our first southern stop was near Reykholt (population 123) in the Gufudalur geothermal area, or the Steam Valley, abundant in hot springs, mudpots, and randomly sprouting stem vents. In this region, the great Geysir ("Gusher"), after which all other sprouting hot springs in the world have been named, was first officially recorded

Opposite page: Svartifoss' remarkable hexagonal basalt columns are formed by the shrinking of cooling lava flows.

BOB JONES PHOTO

Iceland spar is important in optical work because of its double refracting property.

as becoming active in the 13th century.

Deep inside the spring, a 20-meter-deep cavern of boiling water, trapped by colder water from the surface, bursts upwards, relieving pressure and creating a massive eruption of water. Geysir produced eruptions up to 60 meters high until tourists in the early 1900s poured rocks and dirt into it in an attempt to set it off. Only after a major earthquake in June 2000 lowered the water level inside did Geysir resume its eruptions, but only infrequently and with much less height.

RAY GRANT PHOTO

Only chemical analysis can tell which cation—Ca, K or N—dominates this heulandite from Iceland.

Just across the steam field of soupy psychedelic algae and mineral deposits, a few meters from Geysir, is the more faithful Strokkur, or "butter churn." Strokkur emits very predictable and photogenic 20-meter eruptions about every five to 10 minutes. It is important to have a quick cameraman to catch the eruptions, but remember to check which way the wind is blowing before positioning yourself for the shot or you will end up dripping.

After a brief visit to the impressive two-tiered cataract Gullfoss ("Golden Waterfall"), swarming over with tourists from the Golden Circle Bus Tour, we headed farther inland in search of Mount Hekla, Iceland's most infamous volcano.

Our route took us past the flourishing village of Flúdir, the mushroom capital of Iceland, where the commercial benefits of harnessing geothermal energy are well displayed by rows of efficiently maintained greenhouses. Geothermal resources offer Icelandic farmers the best opportunity to produce agricultural products, which would otherwise need to be imported at very high costs from the United States or mainland Europe, in a greenhouse. Even Reykjavík relies on underground pools for its hot water; a shower in the city always smells a bit sulfuric and takes some getting used to!

Surrounding Mount Hekla is the Pjórsádalur valley, a large lava flow desert, which has been frequently remade by eruptions recorded as early as the 9th century, but more recently in 1947, 1970, 1980, 1981, 1991 and 2000. The road to Hekla, little more than a compacted two-wheel track through the black sand, runs through the dark, flat volcanic desert parallel to Hekla's imposing snow-capped crater. By some good fortune, we arrived on a rare day of fairly clear skies and were able to see the perfectly shaped cone at the peak.

According to research done on the ash strata around Hekla, it has been active for at least 6,600 years, with at least 20 eruptions on record since the Viking/Irish settlement was founded. Hekla is positioned along a 40-kilometer-deep fissure formed by the unsteady tectonic plates beneath the country and is considered one of Iceland's most dangerous volcanoes because of its frequent eruptions.

Legend tells that Hekla is actually one of the gateways to hell and provided the eternal flames of damnation to the souls of evil dead. Such a description seems extremely apt considering the enormous amount of death and destruction caused by Hekla's many eruptions since the settlement of the island. The 1947 eruption belched out a cloud of ash that reached as far as Russia and lava flows rampaged through the countryside for 13 months. In 1970, Hekla spewed out over 50 million tons of ejecta, destroying crops and burying nearby farmsteads.

For those adventurous enough to tackle this imposing formation, there is a 7-kilometer walk to the top of the volcano. It takes about a day to complete the climb, but watch out for some nasty local residents: Búrfell and Bjólfell are two trolls known for trying to get local farmers into their stewpot!

continued on next page

Farther down the coast, we reached our first glacier, Eyjafjallajökull, and second volcano, Mount Eyjafjöll. Eyjafjöll has a 4-kilometer-wide cone, which has been formed by numerous eruptions beginning in the Ice Age and continuing into our own Holocene period. The glacier surrounds the volcano, and during the summer months, it melts to create a string of beautiful waterfalls along its steep cliffs.

A short drive down the Ring Road is Iceland's fourth largest glacier, Mýrdalsjökull, at a thickness of 1,000 meters and around 700 square kilometers. It houses another formidable volcano, Mount Katla, or the "cauldron."

Katla reaches a height of 1,250 meters, poking out from under the glacier just slightly. When it erupts, the intense heat sends a glacial tidal wave of water, sand and tephra (volcanic material) pouring through the surrounding areas at a rate five times that of liquid output in the Amazon River—almost 70,000 cubic meters per second.

If you are in for an icy adventure, Vatnajökull Tours (vatnajokull@vatnajokull.com and Dog Steam Tours (dogsteam@simnet.is) run daily snowmobile and dog sled tours of Mýrdalsjökull glacier from May to September. Otherwise, you can easily admire the staggering cliffs and glacial tongues that lick out toward the sea by car or bus along the coastal Ring Road. We also joined in the fun at the curious site of Laufskálavördur, where travelers of many centuries have stacked up little volcanic rock piles for good fortune on their journey.

On the road again, we headed to the eastern side of Iceland with a prime destination in mind: Skaftafell National Park at the edge of Vatnajökull, the world's third largest glacier. One of Iceland's four large national parks, Skaftafell contains numerous hiking trails in the area surrounding Vatnajökull ("Water Glacier"), as well as trails leading over the glacier for those with the proper equipment.

Large amounts of basalt and rhyolite make up the geological character of this area, with some plutonic rock, such as gabbro and granophyre, also visible in some parts. Gabbro is a slow-cooling, intrusive, igneous formation made up of magnesium and ferrous iron that has a gray to greenish-gray color. It is formed during the opening of an oceanic basin, with crystallization taking place at depth. It is a coarse-grained, granular to porphyritic structure showing minor banding. Granophyre is a light reddish, medium-grained, hypabyssal igneous rock formed deep in the Earth.

Particularly impressive was the nearby Svartifoss ("Black Falls") waterfall, reached by an easy hike up through the glacial valley. Svartifoss appears almost from nowhere, with symmetrical basalt columns poking out amongst the endless green. It was one of the most photogenic places we visited. The remarkable basalt columns formed from deep lava flows. When the lava lost heat and shrank, the basalt was cracked vertically into hexagonal columns.

KIERA TARA O'BRIEN PHOTO

The Seltún geothermal area, containing steam vents, gurgling mud pots, and fumaroles, lies on an active volcanic fissure.

Underneath Vatnajökull lie the volcanoes Grímsvötn and Öraefi, whose eruptions create a similar reaction to those of Mount Katla. Trapped beneath the glacier, the intense heat melts the ice above and around the volcanoes, while the sudden release of steam causes the entire glacier to rise by several meters. This allows the melted water to escape, sending great tidal waves onto the lowlands below in an event known as jökulhlaup, a glacial burst. The surrounding lowlands are referred to as sandur, or glacial deserts, specifically formed by the scouring action of rock and broken ice carried by the floods.

To the east of Vatnajökull lies the oldest section of Iceland. Here, the bedrock is estimated to be around 16 million years old, produced by volcanoes that are now extinct. Rich, colorful flora dominates the lowland areas, and bare mountains rise in the background. With a little luck, you might spot one of Iceland's wild reindeer. There is little geothermal activity in this area, but most of Iceland's semiprecious stones and fossil remains can be found here. These include a number of zeolites (stilbite, mesolite, laumontite, chabazite, and analcime), or microporous crystalline solids, generally made up of silicon and aluminum.

Stilbite, a pearly mineral that sometimes has a pink tint, is one of the most commonly collected zeolite minerals. The crystals aggregate together within the vesicles, or petrified bubbles, of volcanic rocks, often resulting in an hourglass structure, in which the crystals can fan out at the top and bottom.

Another popular zeolite, mesolite, occurs in radiating sprays of clear, delicate, needlelike acicular crystals, while laumontite, an opaque, vitreous mineral, often appears in large, columnar crystals protruding beyond a rugged base. Analcime, sometimes known as analcite, forms an interesting crystal shape, an isometric trapezohedron.

Also common in Iceland is augite, found in many igneous rocks, particularly gabbros and basalts, and some hydrothermal metamorphic rocks. Olivine (peridot is the gemstone variety) is found in ultramafic igneous rocks and marbles in flattened tabular to box-shaped crystals. Often in Iceland, olivine is a granular xenolith common to a landscape dominated by volcanic rock varieties rich in magnesium.

Other minerals and fossils found in Iceland include sulfur, steatite, pyrite, jasper, agate, opal without internal fire, and petrified wood and plant stuffs. By special arrangement, Petra Sveinsdóttir will show a number of rare minerals that have been found in the vicinity of Stödvarfjördur (tel. 475 8800).

Around the town of Lón, situated between two large mountain ranges, the landscape is dominated by granite, liparite (a form of rhyolite recognized by Professor Justus Roth, University of Berlin, in 1881), gabbro, and a few other rare rock types. These rocks color the inner ridges of the valley, which formed around 9 million years ago. Near Lón is the 454-meter-high mountain Vestrahorn, one of the few plutonic gabbro formations in Iceland.

Another impressive site is the huge Lakagígar fissure, which stretches 30 kilometers across. During the spring of 1783, the now-dormant volcano Laki erupted in Iceland's deadliest disaster in recorded history. Around 30 billion tons of lava and 90 million tons of sulfuric acid surged to the surface, devastating the livestock, flora, and human population of Iceland. Traces of ash attributed to this eruption have been identified in various stratigraphic studies conducted around the world. The Lakagígar crater row is comprised of large black sand dunes and numerous lava caves. Some of the caves have miniature stalactites formed inside.

continued on page 90

Farther east, when hiking around Flótsdalur, just off the main road near Hallormsstadur, you can follow a trail to the 120-meter-high waterfall known as Hengifoss. At the top of the waterfall is a layer of basalt similar to the polygonal formations at Svartifoss. Below this is a layer of sandstone containing fossilized tree trunks from the Tertiary period (66 million to 2 million years ago).

On one of the eastern fjords is the Helgustadir Mine, which, for many years, was one of the best mines in the world for spar, a mineral used in scientific equipment. Icelandic spar occurred in meter-long specimens. A transparent variety of calcite, spar is dull on the surface, clear on the inside, and coated with stilbite.

It was probably the Danish physicist and mathematician Erasmus Bartholinus (1625-98) who discovered polarized light while working with Icelandic spar. During his professorship at the University of Copenhagen from 1675 to 1698, Bartholinus noticed that the images viewed through Icelandic spar were doubled and one of the images rotated with the movement of the crystal. He was never able to satisfactorily explain how the double refraction occurred, but he was the first to recognize a serious error in Isaac Newton's prominent optical theories.

Following further discoveries and revelations in the theories of optics, Iceland spar was used for many centuries to make the prisms of the polariscope. In particular, Icelandic spar served as the premier material for making microscope lenses. In 1975, the Helgustadir mines were declared a national monument after the production of spar had ceased.

Having explored the southeastern wonders of Iceland, our expedition now ventured to the western and northwestern coasts in search of whales, the Blue Lagoon, and more fish for our master of the fly.

Stratified basalt and rhyolite dominate the rocky and sandy western fjords. In this region, filled with fishing communities and sparsely placed sheep farms, lignite was harvested as a major source of fuel for centuries. Lignite is a variety of coal that appears to retain the structure of the original organic material, typically wood. It is a brownish-black material in an intermediate stage between peat and bituminious coal.

When passing through Borgarland around the human town of Bjartmarssteinn, you might have the privilege of meeting the "hidden people" of Breidafjördur, whose capital city is said to reside inside a large volcanic plug 55 meters high and 100 meters across. It is always important to pay your respects to the local hidden people to ensure that you enjoy good luck in and safe passage through their region.

In the southwest, Seltún, a highly active and extremely smelly geothermal area, is situated on the Reykjanes peninsula, lying on one of the major volcanic faults. We followed a wooden track through the gurgling mudpots and steam vents, covering our noses and mouths to survive the intense smell of sulfur.

RAY GRANT PHOTO

This superb group of Icelandic stilbites shows a typical, pearly luster.

These sulfur deposits were actually mined in earlier periods for a small gunpowder industry on the island. The surface temperature of the steam vents and small pools is estimated at 80 to 100 degrees Celsius. Underground, however, at a depth of 1,000 meters, the temperature reaches at least 200 degrees Celsius. If you can survive the smell long enough, it will take you about 10 minutes to walk the wooden track from the parking area to a large platform overlooking the whole area.

Camping our way across Iceland naturally left our little expedition tired and in need of some pampering, so we headed off to the extremely popular Bláa Lónid, or Blue Lagoon. Located about 40 minutes' drive from Reykjavík, the Blue Lagoon is a natural geothermal spa created by seawater heated from seeping beneath the extensive lava fields nearby. Both pure white and black sands surround the lagoon and line the bottom, squishing in between your toes when you stand. White silica mud is most common and is offered in tubs located around the spa for exfoliation and cleansing. The water is a relaxing 38 degrees Celsius (100 degrees F) and the steamy surrounds, combined with blue-green algae, nourishes the body and the soul. The healing effects of the lagoon are even officially sanctioned by the Icelandic surgeon general.

Our experience at the Blue Lagoon was particularly ethereal. It was sprinkling cold rain that day, which produced a thick mist over the lagoon and increased the steam. The effect was amazing! Clouds of mist wafted over the pools and created hidden spaces in which it seemed that you were the only person floating in the tranquil waters. After many dirty and muddy days in the bush, our troupe was thoroughly refreshed by the unearthly surrounds.

Our journey through Iceland had been an incredible one. The patchwork landscape, which looked as though someone had stuck together the pieces of a geological puzzle in the wrong order, had provided more than enough opportunity for exploration and adventure.

We had come to know the mythology of the landscape, as well. For many Icelanders and Scandinavians, it is equally as important as the scientific nature of their country. It was easy to understand why trolls, fairies, gnomes, and other hidden people enjoyed such a prominent role in Icelandic folk tales and the local mentality after touring the amazing landscape. In some areas of Iceland, one must make a thorough check of the area to ensure that it is not already occupied by a colony of hidden people before one is permitted to construct a building. Many houses also have a smaller replica of the house placed in the front yard for use by hidden people who might require a place to stay for the night while traveling between their cities—good Icelandic hospitality!

Driving back to central Reykjavík on our last day, we passed a new outer suburb dominated by unimpressive concrete houses occasionally painted a bright red or yellow. A lack of wood on the island means that local rock resources provide the cheapest and most available material for construction. We spent our final night in a concrete guesthouse (East Germany, circa 1967, but much more luxurious on the inside) rather than in the tent that had been our home over the last few weeks, a tent designed for two people or three very, very good friends! Flying out of Keflavík airport back to the European mainland, there was no doubt in any of our minds that we would return again one day for yet another adventure of wandering sheep, Martian rocks, concrete architecture, and big, cold glaciers.